DEVELOP National Program

Disasters Project Proposals

Spring 2015

Proposals Snapshot

1. Himalaya Disasters: Evaluating Landslide Hazards in Nepal through Remotely Sensed Data, Event Nowcasting and Crowdsourcing (Goddard)
The proposed project involves three complementary activities to better characterize landslide hazards within Nepal using data evaluation, monitoring and reporting tools: 1) improve a regional landslide catalog with available remote sensing information and mine existing data to create better landslide inventory repository for Nepal, 2) create landslide hazard and vulnerability assessments based on socio-economic datasets available, and 3) help ICIMOD develop, maintain and visualize landslide data and hazard products for regional end users. This project would also involve using the dynamic landslide hazard map developed through this and complementary research and determine how to create real-time "alerts" for potentially susceptible landslide areas that could be distributed to emergency responders.

2. Idaho Disasters II: Using NASA Earth Observations to Identify Savannah and Shrubland Vegetation in Southern Idaho (Goddard & ISU GIS TReC)
This project will use NASA Earth observations to identify vegetation species across southern Idaho because there are large differences in fire susceptibility among vegetation species, so understanding their distribution is important in identifying regions at higher risk for fire. The results of this study will benefit the broad fire community and extend the data products and technical capabilities of the RECOVER decision support system for use by the Bureau of Land Management (BLM) and Idaho Department of Lands (IDL).

3. Malawi & Botswana Disasters: Creating a Flood Forecasting Tool Derived from NASA Earth Observations and Based on Flood Definitions (IRI)
This project aims to create an early warning flood detection and prediction product series targeted at specifically defined (spatially, temporally, and categorically) flood types. The project will focus on using the previously defined flood definitions to assess where skill can be found with the various products, their utility in specific areas, and with particular flood types to assist in the prediction of the flood events.

4. California Disasters: A New Method for Providing Near-Real-Time Active-Fire and Post-Burn Support to Fire Responders Using Data Products Derived from NASA's UAVSAR (JPL)
This project explores the capabilities of UAVSAR-derived polarimetric imagery to provide near-real-time support to active fire responses as well as post-burn imagery to support fire severity assessments.

5. Western US Disasters: Using GRACE-derived Water and Moisture Products as a Predictive Tool for Fire Response in the Western United States (JPL)
The team will analyze correlations between GRACE Data Assimilated Products (GDAPs) surface soil moisture, root zone soil moisture, and groundwater with NDVI values, fuel moisture data, and MODIS-based fire-severity data to establish the potential predictive capability of GDAPs for directing ground-response efforts during fire seasons and fire outbreaks.

6. Peru Disasters & Water Resources: Utilizing NASA Earth Observations to Develop a Comprehensive Water Resources Management Plan for Asunción district in Cajmarca province, Peru (Wise County)
The main objective of this project is to assist Water For People to develop water resources management plans for the Asunción district by: 1) developing comprehensive water resources inventory for the district, 2) forecasting flow rates and water levels in Asunción, and 3) producing historic and predictive flood maps for the Asunción district.

Partners Snapshot

Federal Partners

- Bureau of Land Management, Pocatello Office (End-User)
- Idaho Department of Lands, Boise Field Office (End-User)
- NASA RECOVER Project (Partner)
- NASA Terrestrial Hydrology Program at Goddard Space Flight Center (Partner)
- USDA Forest Service Remote Sensing Applications Center (RSAC) (Partner/End-User)
- Tactical Fire Remote Sensing Advisory Committee (TFRSAC) (Partner/Boundary Organization)

State Partner

- CAL FIRE (End-User)

NGO Partner

- Water For People (End-User/Boundary Organization)

International Partners

- ICIMOD (Partner/Boundary Organization)
- Red Cross / Red Crescent Climate Centre (RCRCCC) (Boundary Organization)
- Instituto Nacional de Defensa Civil del Peru (INDECI) (End-User)

Project Proposals

1. Himalaya Disasters (Goddard)

Evaluating Landslide Hazards in Nepal through Remotely Sensed Data, Event Nowcasting and Crowdsourcing

Objective:

The proposed project involves three complementary activities to better characterize landslide hazards within Nepal using data evaluation, monitoring and reporting tools: 1) improve a regional landslide catalog with available remote sensing information and mine existing data to create better landslide inventory repository for Nepal, 2) create landslide hazard and vulnerability assessments based on socio-economic datasets available, and 3) help ICIMOD develop, maintain and visualize landslide data and hazard products for regional end users. This project would also involve using the dynamic landslide hazard map developed through this and complementary research and determine how to create real-time "alerts" for potentially susceptible landslide areas that could be distributed to emergency responders.

Community Concern:

Nepal is one of the hotspots for landslides activity due to its complex topography, monsoon rains and often poor building practices. Every year, hundreds to thousands of people die in the Himalaya region due to primarily rainfall-triggered landslides. There have been very few regional or global efforts to document where landslides have occurred and estimate potential landslide conditions in near-real time. This system provides a near real-time estimate providing a "warning" of potential landslide activity at the regional scale over Central America and the Caribbean. This system will also be extended to the Himalayan region and possibly Brazil.

End-Users/Partners/Boundary Organizations:

ICIMOD (Partner/Boundary Organization, POCs: Basanta Shrestha/ Director Strategic Cooperation, Birendra Bajracharya/Regional Programme Manager, Manchiraju Sri Ramachandra Murthy/Theme Leader for Geospatial Solutions, Deo Raj Gurung/Remote Sensing Specialist)

This project focuses on working with ICIMOD in Nepal to develop landslide hazard detection, monitoring and reporting systems and products for their end users. Science advisor, Dr. Dalia Kirschbaum, is already in close contact with several Points of Contact at ICIMOD and they will be close collaborators in guiding the product and tool development to ensure regional end user requirements are met. The prototype system supporting the landslide hazard tools is called the Multi-Scale, Multi-Hazard Architecture for Disasters and Sciences (MMADS) and the node for Mesoamerica and Hispaniola is accessible at http://ojo-streamer.herokuapp.com/meso. Through the DEVELOP research effort, the goal is to expand this system to the Himalaya region and provide end-user guided products for regional preparedness and response to landslides.

A quote from a recent e-mail from Deo Raj at ICIMOD encapsulates the interest of the end user group and how this project will engage with ICIMOD for the proposed DEVELOP work:
December 4th, 2014 - "We at ICIMOD are also gearing towards initiating landslide related activities (landslide mapping, hazard/risk assessment and EWS) there is synergy between what you have indicated and what we are planning. We can provide the team with local perspective, data, and help validate the output and test system performance, in addition to help interface with national agencies."

Decision Making Process:

This proposed DEVELOP project reaches a range of different user groups with different operational, research and response objectives. The products, tools and services outlined in this project will be developed in close collaboration with ICIMOD to ensure that they are utilized by end users in the region for situational awareness and informed decision making related to landslide hazards. While there has been published research in Nepal on landslides and landslide hazards, there is currently not a regionally consistent system to integrate data, easily visualize information and share this information through a social networking and crowd sourced environment on landslides. The MMADS system has already established links to easily share information through Facebook, Twitter and other outlets as well as easily visualize and export data through GeoJSON (GeoJSON.org). Leveraging research and capabilities that have already been developed through funded NASA ROSES work, the proposed DEVELOP project will expand the capabilities to a new set of users in Nepal, develop new products and highlight a variety of NASA Earth Science data.

Earth Observations:

Platform	Sensor	Geophysical Parameter
EO-1	ALI	Visible detection of landslide scars
Landsat 5, 7, 8	ETM+, OLI	Visible detection of landslide scars
TRMM	TMPA (TRMM Multi-satellite precipitation analysis) – TMPA will continue after TRMM is decommissioned in ~April, 2015.	Rainfall information
GPM	IMERG (multi-satellite precip analysis). There will be a soft launch of IMERG in January, 2015.	Rainfall
SRTM		Topography

NASA Earth Observations to be Highlighted:
The MMADS system has been prototyped within Mesoamerica and has been developed as part of the NASA ROSES SERVIR activity. This model features TRMM and (soon) GPM data as well as uses SRTM and other remote sensing sources to build the landslide hazard model. Dr. Dalia Kirschbaum is also working with DEVELOP Science Lead Dr. John Bolten on his soil moisture data product which hopefully will be used for improved assessment of antecedent soil moisture conditions. Given the delayed launch of SMAP, we will not plan to integrate SMAP estimate within the DEVELOP project.

Ancillary Datasets:
SEDAC Socio-economic variables at CIESIN – provide multiple socio-economic indicator Datasets

Models:
Landslide Hazard Assessment System (POC: Dalia Kirschbaum (NASA GSFC))

Decision Support & Analyses:

Proposed End Products	Decision Impacting	Current Partner Tool/Method
Global Landslide inventory	Identification of landslide locations through remote sensing imagery	Online landslide editor, global landslide catalog
Regional landslide hazard assessment system	Estimation of potential landslide activity in near real-	Landslide Hazard Assessment System

	time	
Landslide vulnerability products	Identification of socio-economic impacts of landslide hazards	Regional and local emergency response, government or decision making personnel
Real-time generation of landslide "alerts" based on landslide hazard model	Real-time information to ICIMOD and other identified end user groups for situational awareness of current landslide potential conditions	MMADS system within Himalayas, focusing on Nepal.

Global Landslide Inventory – Expansion of the Global Landslide Catalog with the objective of providing a global view of landslide hazards. This catalog will also be supplemented with landslide identified from remote sensing imagery from visible sensors such as EO-1 and Landsat missions.

Regional Landslide Hazard Assessment System – The regional landslide model will be evaluated for Nepal as part of the migration of MMADS framework to the Himalaya region. Together with ICIMOD, the proposed work will develop complementary products and databases to the landslide hazard model with direct guidance from end users. Dr. Dalia Kirschbaum has a NASA ROSES funded project through SERVIR to conduct a feasibility study of the SERVIR-Himalaya node for potential transfer of the landslide hazard model to this area. The proposed project builds off of this research to develop new tools and products for Nepal.

Landslide Alerts within MMADS system – Once the MMADS system has been migrated to Himalaya region, the model will be used to generate landslide "alerts" of particularly hazard prone areas. As part of this activity, an app may be created to port landslide reporting and remote sensing information to a mobile device. This development has already begun, but this work could support this development activity, if expertise is available.

Project Details:
National Application Area Addressed: Disasters
Source of Project Idea: This work is supported by the SERVIR Science Team and builds on previous research in this field, particularly from science advisor Dr. Kirschbaum.

Advisor: Dalia Kirschbaum, NASA GSFC
# of Participants Requested: 3
Project Timeline: 3 Terms: 2015 Spring to 2015 Fall
Study Location: Nepal
Period being Studied: Retrospective analysis and Near Real-Time
Multi-Term Objectives:

- **Term 1(Proposed Term)** – The first term will involve data acquisition, processing and image analysis of landslide information. There is already a wealth of potential landslide data in Nepal available through publications and via ICIMOD. 1-2 students will work to update landslides events within the landslide editor framework that has been recently launched as well as develop a methodology for image analysis of landslides using remote sensing data. A third student with more programming expertise will be provided all of the code (available in GitHub) to begin transitioning the MMADS node to Nepal and establishing a regional node in this area. At the beginning of this term, the team will work very closely with ICIMOD personnel and possibly the DEVELOP program at ICIMOD to define the key products of interest to ICIMOD and its end users. By the end of the term, the team will use

the landslide inventory information obtained from their research to develop and test a susceptibility map for the region.

- **Term 2**– The second term will focus on fully implementing and evaluating the Himalayan node of the system. Using the inventory developed in the first term, the DEVELOP team will create a set of landslide vulnerability indicators to better represent the impact of landslides in Nepal. The team will work to port products developed in the first term into this system and develop tutorials and documentation for end users of this material.
- **Term 3 –** If awarded, students during this term would take the landslide system, which will be routinely run at ICIMOD and determine how to create landslide "alerts" for the landslide hazard system. Using the alert concept, they will develop a crowd sourcing tool utilizing the existing tools within MMADS to validate the alerts made as well as improve the landslide event reporting method, potentially with the development of a mobile app. A mobile app code base has already been developed as an off shoot of the funded work, but more work is needed to make this a functioning application. The app development is contingent on the expertise of the students.

2. Idaho Disasters II (Goddard)

Using NASA Earth Observations to Identify Savannah and Shrubland Vegetation in Southern Idaho

Objective:

This project will use NASA Earth observations to identify vegetation species across southern Idaho because there are large differences in fire susceptibility among vegetation species, so understanding their distribution is important in identifying regions at higher risk for fire. The results of this study will benefit the broad fire community and extend the data products and technical capabilities of the RECOVER decision support system for use by the Bureau of Land Management (BLM) and Idaho Department of Lands (IDL).

Community Concern:

Wildfire is a common hazard throughout semiarid savanna ecosystems. Following fire, ground vegetation is typically eliminated, leaving the landscape devoid of cover. These communities may then experience a series of adverse changes due to landslides, soil erosion, and invasive plant infestations. Wildfires have occurred for millennia, but climate change and related factors appear to be increasing their frequency and intensity, creating a demand for advanced wildfire decision support capabilities to identify fire susceptibility. Our end users can use our analyses to "allocate resources to regions that are more susceptible to fires" (Mike Kuyper, BLM).

End-Users/Partners/Boundary Organizations:

Bureau of Land Management, Idaho State Office and cooperating District Offices (End-User, POCs: Steve Jirik, Natural Resource Specialist; Mike Kuyper, Supervisory Natural Resources Specialist)

Idaho Department of Lands, Boise Field Office (End-User, POCs: Dixie Booker-Lair, GIS Analyst; Robin Dunn, GIS Specialist)

RECOVER Project (Partner, NASA Goddard POCs: John Schnase, Mark Carroll; Partner/Boundary Organization, Idaho State University POC: Keith Weber)

The entire Fall 2014 Idaho Disasters team met with our project end-users in Idaho in October, 2014. We discussed at length various products and tools that will be useful for our end-users as well as other government and local agencies that were in attendance. The vegetation map of southern Idaho will be sent directly to our end-users and incorporated into the RECOVER platform (see Notes) which is currently available and used by our end-users. Our end-users will use the vegetation map in conjunction with their current resources to identify regions of higher

fire susceptibility based on vegetation distribution in order to allocate their resources more efficiently.

Decision Making Process:
Currently, the BLM uses vegetation moisture measurements that are collected at two-week intervals in discrete locations across the state. The measurements are collected from March to October by various national, state, local, and independent agencies and inputted into the National Fuel Moisture Database. Areas with drier vegetation receive resources such as helicopters, dozers, and other fire suppression equipment from field offices (the BLM has 16 field offices in Idaho) that are less susceptible. The Idaho Department of Lands follows similar guidelines, but the number of fires they respond to is much lower since most of the land in southern Idaho is managed by the BLM.

Earth Observations:

Platform	Sensor	Geophysical Parameter
Landsat 8	OLI	Vegetation imagery (visible & infrared)
Terra	ASTER, MODIS	Infrared vegetation imagery, NDVI

NASA Earth Observations:
This project does not need to just identify the location of vegetation, but classify different vegetation into fire susceptibility classes. Grasses are most susceptible, followed by shrubs and then woodlands. Within these general vegetation classifications, certain species have phenologies that can contribute to higher fire susceptibilities. Using the visual imagery of the landscape from Landsat 8, with a spatial resolution of 15m after panning, allows us to identify general classes of vegetation. With ground-truthing data on specific species of vegetation in the study area, we can classify pixels even further. Vegetation will also have different signatures in the infrared bands, which can be further analyzed using Landsat 8 OLI and Terra ASTER. The NDVI gathered from the MODIS instrument on Terra also provides another vegetation metric that may be used to distinguish between vegetation classes.

Ancillary Datasets:
National Fuel Moisture Database
In situ data from partners at Idaho State University and our end-users of current vegetation at various locations

Decision Support Tools, and Analyses:

Proposed End Products	Decision Impacting	Current Partner Tool/Method
Vegetation Map	Identify regions with vegetation that ignite easier and dry out faster	Vegetation moisture measurements in National Fuel Moisture Database

Vegetation Map – Extensive map across southern Idaho of three main vegetation classes: grass, shrubs, and trees. If possible, classify into smaller classes based on vegetation phenology. We will use classification tools on the remote sensing products to identify vegetation classes.

Project Details:
National Application Areas Addressed: Disasters, Ecological Forecasting, Water Resources, and Health and Air Quality
Source of Project Idea: This project is associated with Phase 2 operational deployment of the RECOVER DSS sponsored by NASA's Applied Sciences Program under ROSES A.35 - Wildland Fires (See Phase 1 and Phase 2 proposals titled " RECOVER: Rehabilitation Capability Convergence for Ecosystem Recovery — An Automated Burned Area Emergency Response Decision Support

System for Post-fire Rehabilitation Management of Savanna Ecosystems in the Western US" for additional information).

Advisors: John Schnase (NASA GSFCAffiliation), Mark Carroll (NASA GSFC), Keith Weber (ISU GIS TReC)
 # Of Participants Requested: 4, two assigned to each of locations, GSFC and ISU GIS TReC.
Project Timeline: 3 Terms: 2014 Fall (Start) to 2015 Summer (Completion)
Study Location: Southern Idaho
Period being Studied: March 2014 – August 2014

Previous Related DEVELOP Work:
Idaho Disasters I: Using NASA Earth Observations to Create a Database and Determine Regional and Temporal Wildfire Susceptibility in Idaho Savannahs - Fall 2014 (GSFC)

Multi-Term Objectives:

- **Term 1** – During this term, the team investigated the relationship between NDVI, surface temperature, and fire occurrence. The remote sensing parameters did not have any strong correlations with the number of fires each year. A secondary analysis compared the NDVI at locations that burned versus those that didn't burn. The participants found that in April the NDVI at burned locations was significantly higher than unburned regions, which may be an indicator of more fuel for fires later in the year.
- **Term 2 (Proposed Term)** – The objective of this term is to use Landsat Imagery to identify vegetation to the genus level. These vegetation maps are helpful to the end-users since different species of vegetation have different attributes that make them more susceptible to fire and have different management techniques.
- **Term 3** – The goal of the final term is to investigate vegetation and soil moisture and its relationship with fire susceptibility. If there is a strong relationship, then we can integrate our findings on NDVI from the first term, plotted against the vegetation cover from the second term, and stacked with vegetation moisture results into a fire susceptibility map that aids wildfire managers in allocating resources prior to the active fire season.

3. Malawi & Botswana Disasters (IRI)

Creating a Flood Forecasting Tool Derived from NASA Earth Observations and Based on Flood Definitions

Objective:
This project aims to create an early warning flood detection and prediction product series targeted at specifically defined (spatially, temporally, and categorically) flood types. The project will focus on using the previously defined flood definitions to assess where skill can be found with the various products, their utility in specific areas, and with particular flood types to assist in the prediction of the flood events.

Community Concern:
Globally, floods are among the most devastating natural disasters affecting human livelihoods and economic resources. Flooding can occur due to a range of catalysts such as heavy rainfall, rapid snowmelt, monsoons, levee/dam breaks, and storm surge. Events can last for varying time periods as well, from hours to several weeks. Along with the direct threat of floods, previous studies have linked inundation to outbreaks of vector-borne diseases. Recent epidemics of vector-borne diseases (such as Leishmaniasis) have caused an estimated 100,000 deaths and have renewed the impetus for defining the ecological boundaries of the vector. Future work on

this project could work on using the new inundation products to create an Early Warning System (EWS) tool for both flooding as well as outbreaks of vector-borne disease.

End-Users/Partners/Boundary Organizations:
Red Cross / Red Crescent Climate Centre (RCRCCC) (Boundary Organization, POC: Erin Coughlan, Senior Climate Specialist) - Red Cross: Malawi, Botswana, and Regional Center for South Africa (End-User)

Contact has been made with the project partner, who is willing to collaborate and share data. The Regional Centre for Mapping and Resources for Development (RCMRD) will be able to present the decision support tool on a web-based platform to increase outreach. The handoff of the final product will be done in person.

Decision Making Process:
The use of accessible remotely sensed data is critical to potential partners as it increases the temporal and spatial scales of proposed projects. Currently the end users have the IFRC extreme heavy rainfall forecast tool at their disposal, but not all inundation is related to heavy rainfall. Examining the skill of the heavy rainfall forecast along with how it correlates to inundation can help improve flood risk maps. With these products in the IRI data library, project partners at the RCRCCC will be able to better prepare countries for both inundation events and for epidemiological outbreaks of vector borne diseases.

Earth Observations:

Platform	Sensor	Geophysical Parameter
QuikSCAT	SeaWinds	Inundated areas
Terra	MODIS	Inundated areas, water body delineation
Aqua	AMSR-E	Inundated areas, water body delineation
Landsat 7	ETM+	Water body delineation
Landsat 8	OLI/TIRS	Water body delineation
ALOS	PALSAR	Inundated areas
TRMM	TMI	Precipitation

NASA Earth Observations to be Highlighted:
The project will focus on developing new methods to map water bodies and inundated areas based on PALSAR on ALOS, Aqua AMSR-E, QuikScat SeaWinds, Aqua and Terra MODIS, Landsat 7/8 ETM+/OLI/TIRS, and GCOM-W1 AMSR-2 data. The team will crosscheck the water bodies with data from three sources; the CUNY/SWaMPS inundated fraction values, the NASA Goddard Space Flight Center MODIS Near Real-Time Global Flood Mapping Project (NRT-GFM), and the Dartmouth Flood Observatory (DFO).

Decision Support & Analyses:

Proposed End Products	Decision Impacting	Current Partner Tool/Method
Early Warning System	Where/How to allocate resources before a flood event occurs	IFRC heavy rainfall forecast

Early Warning System – After the best method(s) of identifying flood inundation have been selected, it will be used in an attempt to validate and build upon the IFRC forecasts to design a more accurate early warning system for flood events.

Project Details:
National Application Area Addressed: Disasters

Source of Project Idea: The idea for the project originated from work on understanding the relationship between leishmaniasis and flood inundation for the past three terms.

Advisor: Dr. Pietro Ceccato (Research Scientist, Lead Environmental Monitoring Program, The International Research Institute for Climate and Society, The Earth Institute, Columbia University)
# of Participants Requested: 2
Project Timeline: 2 Terms
Study Location: Malawi and Botswana
Period being Studied: 1985-2014

Previous Related DEVELOP Work:
Fall 2013 (IRI) - Sudan Health and Air Quality: Using MODIS, Landsat, and TRMM to better understand the dynamics of water bodies in relation to Leishmaniasis (Kala Azar) in Sudan

Spring 2014 (IRI) - East Africa Health and Air Quality I: Using NASA Earth Observations as a Tool for Understanding the Relationship Between Rainfall Extreme Events and Inundation in East Africa to Predict Epidemic Dynamics

Summer 2014 (IRI) - East Africa Health and Air Quality II: Creating a Flood Forecasting Tool Using NASA Earth Observations Built on the Understanding of the Relationship between Rainfall Extreme Events, Inundation, and Epidemic Dynamics in East Africa

Fall 2014 (IRI) - East Africa Health and Air Quality III: Using a Flood Forecasting Tool Built from NASA Earth Observations and Creating Inundation and Epidemiological Early Warning Systems to understand the relationship between Rainfall Extreme Events, Inundation, and Epidemic Dynamics in East Africa

Multi-Term Objectives:

- **Spring 2015 (Proposed Term)** – This proposed project aims to create an early warning flood detection and prediction product series targeted at specifically defined (spatially, temporally, and categorically) flood types. The project will focus on using the previously defined flood definitions to assess where skill can be found with the various products, their utility in specific areas, and with particular flood types to assist in the prediction of the flood events.
- **Summer 2015** – Continuation of the work from the previous term and possibly expand use of methodologies to other locations in the region.

4. California Disasters (JPL)

A New Method for Providing Near-Real-Time Active-Fire and Post-Burn Support to Fire Responders Using Data Products Derived from NASA's UAVSAR

Objective:
This project explores the capabilities of UAVSAR-derived polarimetric imagery to provide near-real-time support to active fire responses as well as post-burn imagery to support fire severity assessments.

Community Concern:
Destructive wildfires in California have increased in number and size within the last decade. Severe drought conditions in California have exacerbated the risk of fire and the necessity for fast, effective fire response. Currently, fire responders in California such as the California Department of Forestry and Fire Protection (CAL FIRE) are limited to visual assessments when

responding to on-the-ground fires. Erratic fire behavior, smoky conditions and uneven terrain make accurately assessing the intensity of a fire and its growth potential during an active burn difficult. Post-imagery analysis using MODIS and Landsat scenes provides after-the-fact assessments of burn intensity through changes in reflectance, but this parameter remains non-evaluable during an active fire. As the 2009 Station fire in the Los Angeles area showed, small fires can quickly grow to raging infernos when the fire severity potential is not accurately gauged.

End-Users/Partners/Boundary Organizations:
CAL FIRE (End-User, POC: Chris Starnes, Deputy Chief for Operations Support)

Contact has been made with two CAL FIRE persons. Chief Marc Hafner was the initial contact for this proposal. He communicated the lack of remote sensing in CAL FIRES' current response procedures and expressed that the novel approach contained in this project could be extremely useful to fire responders. Deputy Chief Chris Starnes met with JPL Center Lead C. Rains at the Tactical Fire Remote Sensing Advisory Committee meeting in Reno, NV, in October 2014. He expressed interest in this project and will be the POC for CAL FIRE.

The results of this project would be communicated through a presentation at the end of the term which would summarize the effectiveness of this method of fire-monitoring and post-burn assessment, and provide additional information about processing techniques. The benefits to CAL FIRE would be access to near-real-time imagery of active fires for better direction of monitoring and response efforts.

Decision-Making Process:
Currently, fire response by CAL FIRE is managed through on-ground and in-air visual inspection during fires. Infrared imagery is available through the National Infrared Operations program in Idaho. This program provides once-per-night flight scans during a fire-response campaign, producing just a few images. Some other remote-sensing approaches have been field-tested with mixed results. CAL FIRE also uses MODIS products with low temporal and spatial resolution (1 km, daily) for synoptic views during active fire responses and for post-burn assessments. Since radar penetrates smoke and has high resolution, UAVSAR radar imagery has the potential to be a powerful tool for fire-responders both during a fire and in post-fire severity mapping.

Earth Observations:

Platform	Sensor	Geophysical Parameter
Gulfstream III	UAVSAR	Polarimetric SAR imagery (PolSAR)
Aqua & Terra	MODIS	Normalized Burn Ratio (dNBR)
Landsat 7	ETM+	Normalized Burn Ratio (dNBR)
Landsat 8	OLI	Normalized Burn Ratio (dNBR)

NASA Earth Observations to be Highlighted:
This project presents an innovative use for NASA's UAVSAR instrument. Current active-fire monitoring practices depend on visual, daytime observations made by humans, with some limited infrared remote-sensing data available at night. Post-burn assessments are conducted remotely using MODIS data at 1 km resolution. Radar instruments such as NASA's Gulfstream III-mounted UAVSAR are cloud- and smoke-penetrating and "see" as well at night as during the day because they do not depend on solar illumination. The resolution of radar products is on the order of meters. Polarimetric L-band SAR has well-known characteristic backscatter variations with respect to changes in vegetation and forest canopies. These characteristics suggest that radar could be ideal for fire-detection efforts. Although it has been known for a while that the

UAVSAR instruments can detect fires and fire-burnt regions, this capability has not yet been used for active-fire or post-fire monitoring.

Data from the MODIS instruments on the Aqua and Terra satellites as well as the ETM+ and OLI on Landsat 7 and Landsat 8, respectively, will be used to create dNBR images which will be compared with PolSAR imagery from the UAVSAR to assess the effectiveness of using airborne radar to produce useful post-fire products.

Decision Support & Analyses:

Proposed End Products	Decision Impacting	Current Partner Tool/Method
Active Fire Radar Imagery and Analysis	Where CAL FIRE and the Forest Service direct fire-response efforts	Visual inspection at fire site and in the air
Post-burn Radar Imagery and Analysis	Where CAL FIRE and the Forest Service allocate post-fire resources	Aerial imagery, field surveys, and MODIS imagery

Active Fire Radar Imagery and Analysis – PolSAR imagery of active fires will be created and analyzed for usefulness in accurately delimitating fire boundaries and assessing fire intensity. The analysis will summarize what information can be derived from the imagery with certainty, and will include a discussion of error sources and error abatement.

Post-burn Radar Imagery and Analysis – PolSAR imagery of burnt areas will be analyzed for usefulness in describing burn severity and type, as well as land conditions post-fire. The analysis will summarize what information can be derived from the imagery with certainty, and will include a discussion of error sources and error abatement. Similarities and differences between MODIS and Landsat dNBR products and UAVSAR post-burn products will be analyzed to help the end-users decide which technique is most effective for post-burn damage assessment.

Project Details:
National Application Area Addressed: Disasters
Source of Project Idea: This project resulted from discussions at Caltech (Prof. Mark Simons and Graduate Student Brent Minchew) about potential use of SAR-based products for near real-time fire line detection. Based on previous experience with polarimetric radar, Minchew suggested one of the approaches proposed herein as well as conducted the first proof-of-concept application using the Station and Crown Fire examples (see included figure).

Advisors: Dr. Mark Simons (California Institute of Technology), Dr. Sang-ho Yun (Jet Propulsion Laboratory)
# of Participants Requested: 3
Project Timeline: 1 Term: Spring 2015
Study Location: California
Period being Studied: 2007 - Present

5. Western US Disasters (JPL)

Using GRACE-derived Water and Moisture Products as a Predictive Tool for Fire Response in the Western United States

Objective:

The team will analyze correlations between GRACE Data Assimilated Products (GDAPs) surface soil moisture, root zone soil moisture, and groundwater with NDVI values, fuel moisture data, and MODIS-based fire-severity data to establish the potential predictive capability of GDAPs for directing ground-response efforts during fire seasons and fire outbreaks.

Community Concern:

Drought conditions in the western United States have given rise to some of the worst fire seasons on record in the last few years. One of the biggest contributing factors to fire danger is fuel moisture content (FMC). Low FMC means higher fire risk, as well as higher potential fire severity. Previous attempts to remotely sense FMC have faced difficulty, in part because fuel often lies close to the ground and thus out of sight of most sensors. Furthermore, studies have shown the that fuel accumulation occurs in wet years, so both wet and dry years are needed in sequence for increased fire risk and increased potential fire severity. A remotely-sensed FMC product combined with an analysis of yearly wet and dry patterns could potentially provide fire managers and responders with a powerful predictive tool for understanding fire risk and response.

End-Users/Partners/Boundary Organizations:

Tactical Fire Remote Sensing Advisory Committee (TFRSAC) (Partner and Boundary Organization, POC: Everett Hinkley, National Remote Sensing Program Manager)

USDA Forest Service Remote Sensing Applications Center (RSAC) (Partner and End-User, POC: Brad Quayle, RS/GIS Specialist)

NASA Terrestrial Hydrology Program at Goddard Space Flight Center (Partner, POC: Dr. Matt Rodell, Laboratory Chief of Hydrological Sciences)

The Tactical Fire Remote Sensing Advisory Committee (TFRSAC) is a joint think tank for the FS and NASA, investigating how to leverage NASA capabilities toward fire management. Contact with Everett Hinkley was made through JPL scientist Justin Boland. During an introductory telecon, the need for a predictive fire-severity product was established. Everett Hinkley is interested in participating as a partner.

The USDA Remote Sensing Applications Center (RSAC) in Salt Lake City offers fire-support remote sensing products to OTG agencies. POC Brad Quayle also works with the National Interagency Coordination Center to provide predictive services showing short- and long-term fire risk on both regional and national levels. Risk assessment is an active area that is continually looking for improvement and new ideas. Mr. Quayle was contacted via email and phone and expressed strong interest in this project.

Dr. Matt Rodell is in charge of the team that produces GDAPs at Goddard Space Flight Center. DEVELOP national advisor Dr. Kenton Ross has previously been in contact with Dr. Rodell regarding GDAP data. Dr. Ross will serve as a liaison for data acquisition.

The results of this project will be communicated to TFRSAC and RSAC through an update at the end of the first term and a presentation at the end of the second term. If the methodology proves successful, the DEVELOP team will also offer tools and tutorials as appropriate to the partners for further development and incorporation of fire-severity risk maps into their toolkits. The hand-off will be conducted remotely. This product will serve as the basis for a new approach

that could provide OTG response agencies with important fire-severity risk information for a given year.

Decision Making Process:
Currently RSAC uses MODIS, VIIRS, and AVHRR data to monitor active fires in the CONUS. They also create post-fire severity maps using remote sensing, which are used to predict erosion and other effects after a fire. RSAC GIS specialist Brad Quayle also works with the National Interagency Coordination Center to provide fire predictive services such as Fuels and Fire Behavior Advisories based on modeling and in situ measurements.

Earth Observations:

Platform	Sensor	Geophysical Parameter
GRACE	GRACE	*GRACE Data Assimilated Products (GDAPs) for groundwater, root zone soil moisture, and surface soil moisture*
Landsat 8	OLI/TIRS	*NDVI/Fire intensity*
Landsat 7	ETM+	*NDVI/Fire intensity*
Terra	MODIS/ASTER	*NDVI/GFED4 burned area*
Aqua	MODIS	*NDVI/GFED4 burned area*

NASA Earth Observations to be Highlighted:
"GRACE is unique in its ability to sense water stored at all levels and data assimilation can be used to spatially and temporally disaggregate and vertically decompose coarse-resolution GRACE terrestrial water storage into components of groundwater, soil moisture and snow" (Houborg et al., 2009). Products derived in this fashion have been shown to be consistent with other water-monitoring indices, such as those provided by the National Drought Mitigation Center. These products may provide a new approach for estimating fire risk through fuel moisture content as well as fire-severity risk based on alternating wet- and dry-year patterns that have previously been difficult to measure via remote sensing. GDAPs have a resolution of 25 km which could be combined with the MODIS fire data set and the Global Fire Emissions Database (GFED) at UC Irvine, and also compared with vegetation indices from MODIS, Landsat, and ASTER to create a predictive fire product based on fuel accumulation and dryness. Fire predictive products based on GRACE data could help with national-scale early fire management and provide a decision-support tool when combined with other data sources such as weather conditions and topography, what assets are at risk and where people are at risk.

Ancillary Datasets:
Historical fire records in the CONUS (source TBD)
National Fire Danger Rating Fuel Model Map (http://www.wfas.net)

Models:
GRACE Data Assimilated Products for groundwater, root zone soil moisture, and surface soil moisture, based on Land Catchment model

Decision Support & Analyses:

Proposed End Products	Decision Impacting	Current Partner Tool/Method
Analysis of Correlations between FMC and GDAPs	Identification of high-risk fuel conditions	In situ measurements
Analysis of Correlations between Fire Occurrence and Severity and GDAPs	On-the-ground response to fire ignition	None—new method
GDAP-Based Fire Risk Map	On-the-ground response	In situ measurements and fuel

	to fire ignition	moisture modeling
GDAP-Based Fire Risk Map Analysis Tool	On-the-ground response to fire ignition	Various modeling

Analysis of Correlations between FMC and GDAPs – A timeseries depicting how well the Grace Data Assimilation Products correlate with fuel moisture content.

Analysis of Correlations between Fire Occurrence and Severity and GDAPs – A timeseries depicting how well the Grace Data Assimilation Products correlate with historical fire severity. This analysis will include wet/dry year pattern identification and FMC data.

Fire Risk Map – Projections for fire-severity risk based on previous analyses.

Risk Map Analysis Tool – A methodology for generating above maps.

Project Details:
National Application Area Addressed: Disasters
Source of Project Idea: Brainstorming session with J.T. Reager – GRACE scientist

Advisor: J.T. Reager (JPL)
# of Participants Requested: 3
Project Timeline: 2 terms: 2015 Spring to 2015 Summer
Study Location: US west of the Mississippi River: Arizona, Arkansas, California, Colorado, Idaho, Iowa, Kansas, Missouri, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, Wyoming
Period being Studied: 2003 to Present

Previous Related DEVELOP Work:
Texas Disasters: Utilizing NASA EOS to Assess Burn Severity, Risk Mapping and Effects on Air Quality Caused by the 2011 Texas Wildfires - Fall 2011 (Langley Research Center)

Multi-Term Objectives:
- **Term 1(Proposed Term)** – Obtain and input all relevant data into ArcGIS. Preliminary analysis of GDAP correlations with FMC and fire occurrence and severity following wet/dry year patterns using GFED4 records.
- **Term 2** – Conclude analyses. Incorporate results of Term 1 into risk map and map-generation methodology to be shared with partners.

Notes:
https://ams.confex.com/ams/pdfpapers/161080.pdf

Chen, Y., I. Velicogna, J. S. Famiglietti, and J. T. Randerson (2013), Satellite observations of terrestrial water storage provide early warning information about drought and fire season severity in the Amazon, J. Geophys. Res. Biogeosci., 118, 495–504, doi: 10.1002/jgrg.20046.

6. Peru Disasters & Water Resources (Wise County)

Utilizing NASA Earth Observations to Develop a Comprehensive Water Resources Management Plan for Asunción district in Cajmarca province, Peru

Objective:

The main objective of this project is to assist Water for People to develop water resources management plans for the Asunción district by: 1) developing comprehensive water resources inventory for the district, 2) forecasting flow rates and water levels in Asunción, and 3) producing historic and predictive flood maps for the Asunción district.

Community Concern:

Many developing countries, like Peru, struggle with providing water security and sanitation services. *Water For People*, a non-profit organization currently working with the Peruvian government to establish better water resources management systems lacks adequate local datasets necessary for their projects. Water For People seeks to provide water and sanitation systems to the people of seventeen different villages and to improve conditions for the 40% of the population whose systems are deemed unsustainable or in poor condition. Additionally, they also aim at assisting the Peruvian government with flood risks mitigation, an important part of water resources management. As reported by ReliefWeb, a service provided by the UN Office of Humanitarian Affairs (OCHA), in 2008, floods in Peru affected over 45,012 people, and resulted in enormous economic losses. These losses particularly affected the agriculture sector, which is the largest source of income for Peru (contributing13% of the Gross Domestic Product, and employs approximately 10,000,000 Peruvians).

End Users/ Partners/ Boundary Organizations:

Water for People (End-User, POC: Mark Duey, Head of Program Quality, and Francisco Soto, Director for Peru)

Instituto Nacional de Defensa Civil del Peru (INDECI) (End-User, contact initiated through Water For People)

The project idea arose while discussing the results from DEVELOP's Fall 2014 project on Peru Water Resources. The original project focused on the La Libertad region of Peru. The partners strongly felt the need to validate the mathematical models and also get assistance in training local teams on conducting a similar study in Asunción district in Cajamarca Province. *Water for People* conduct their work in three stages: determining the water balance, determining the water security and developing a comprehensive water management plan (which includes assessing flood risk). The first two projects (summer and fall 2014) developed tools and methodologies required to determine different parameters of water balance and the proposed project will assist the partners to utilize NASA Earth observations and mathematical models to achieve the second and third steps. INDECI is directly responsible for disaster management in Peru. Partners from Water for People are currently in contact with INDECI and Consejo de Cuenca who would potentially partner with DEVELOP in implementing flood risk assessment.

Decision Making Process:

Peru's 2009 Water Law enhanced the National Water Resources Systems, prioritized water usage, and defined water usage rights. However, it left control of the water regulations to the federal government, which can have implications for the local governments. Current flood disaster management plans are incomplete and there are not enough proactive plans to prevent widespread disaster. Currently Water for People in partnership with local governments, is developing water resources management plans. However, because of the lack of in-situ data, Water For People wishes to incorporate remotely sensed data from NASA Earth Observing Systems to help augment currently available in-situ data. The project would assist local policy

makers to develop stronger and research-backed efforts to manage floods, improve water conservation and storage, increase the supply of irrigation water and ameliorate drinking water supply systems.

Earth Observations:

Platform	Sensor	Geophysical Parameter
Landsat 5	Thematic Mapper (TM)	Surface Reflectance
Landsat 8	Operational Land Imager (OLI)	Surface Reflectance
Aqua/Terra	Moderate Resolution Imaging Spectroradiometer (MODIS)	Surface Reflectance
Tropical Rainfall Measuring Mission (TRMM)	Multi Satellite Precipitation Analysis - Precipitation Radar (PR)	Rainfall
Terra	Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)	Elevation data

NASA Earth Observations to be Highlighted:
Landsat 8 (OLI) / Landsat 5 (TM) – Landsat imagery will allow visual identification of the flooded regions. A supervised classification map can help to identify flood affected areas. Normalized Differential Water Index (NDWI) maps can be calculated to delineate water from the surrounding area
Aqua/Terra (MODIS) – MODIS surface reflectance data can be utilized in case of large study areas to identify flooded regions
TRMM (PR) – Precipitation measurements from TRMM gives rainfall data which will be used as an input for hydrologic models.
Terra (ASTER) – Elevation data from ASTER will be used as inputs for hydrologic models

Ancillary Datasets:
Modern Era Retrospective-Analysis for Research and Applications (MERRA)
Temperature data from Giovanni Database
Rain gauge data from local weather stations

Models:
Soil and Water Assessment Tool (SWAT) (Potential POC: Dr. Yang Shao, Virginia Tech – Contact has been made to seek assistance with model calibration and waiting on confirmation)
Integrated Flood Analysis System (IFAS) (POC: To be determined)

Decision Support and Analysis:

Proposed End Products	Decision Impacting	Current Partner Tool/Method
Elements of Water Budget	Conducting the regions' water resources inventory and planning water distribution systems	Field surveys
Flood Inundation Map	Planning evacuation routes, insurance coverage and urban planning	Aerial imagery and field surveys.
Flood Risk Map	Planning evacuation routes, insurance coverage and urban planning	Aerial Imagery and field surveys (flood risk maps are currently available only for coastal regions prone to tsunami)

Elements of Water Budget - The team will identify the different elements to estimate water budget for the study area. SWAT model will be predominantly used along with METRIC to quantify and map the parameters involved in the water budget. The methodologies created in Fall 2014 for La Libertad study area will be applied to the new study area.

Flood Inundation Map - Inundation maps show the extent of flooding expected spatially over a given area. Maps of this nature can be used to enhance flood risk preparedness, communication, warning, response and mitigation. Landsat 5 and Landsat 8 surface reflectance data will be used to derive flood inundation maps.

Flood Risk Map - Flood risk maps that take into account socio economic as well as geographic parameters will provide a detailed product highlighting the risk associated with specific areas. Combining elevation data from ASTER, rainfall data from TRMM and in situ data (depends on availability) and by weighing each parameters, flood risk maps will be derived.

Project Details:
National Application Area Addressed: Water Resources and Disasters
Source of Project Idea: DEVELOP has worked on two projects with Peru in previous terms which led to contacts with Water for People. The proposed project originated during a discussion with the partners from Peru during Fall 2014 Closeout.

Advisor: Kenton Ross, NASA DEVELOP National Advisor
# of Participants Requested: 4
Project Timeline: 2 terms: Spring 2015 and Summer 2015
Study Location: Asunción district in Cajmarca province, Peru
Period being studied: 2007 – 2014 (3 major floods identified during 2008, 2013 and 2014)

Previous Related DEVELOP Work:
Peru Water Resources: Utilizing NASA EOS Evapotranspiration data to assist in the development of water budget for Gran Chimu Province, Peru - Summer 2014 (Langley)

Peru Water Resources II: Utilizing NASA Earth Observations to Develop a Comprehensive Water Budget for La Libertad region, Peru - Fall 2014 (Wise)

Term 1: (Spring 2015 – Proposed term)
The main objectives of this term are to identify elements of Water budget by conducting a water resources inventory and provide the partners with necessary data and methodology. The team will also validate and calibrate the SWAT model for La Libertad region and assist in capacity-building with training through webinars. Necessary models and data to estimate the flood risk assessment would be identified. Trial run of models will be conducted and initial contacts with partners from National Civil Defense will be made during this term.
Term 2: (Summer 2015)
The main focus of this term will be on flood modeling in identified study areas and deriving flood inundation maps. IFAS model will be utilized for flood modeling. Tutorials will be created in both English and Spanish to assist the local and federal