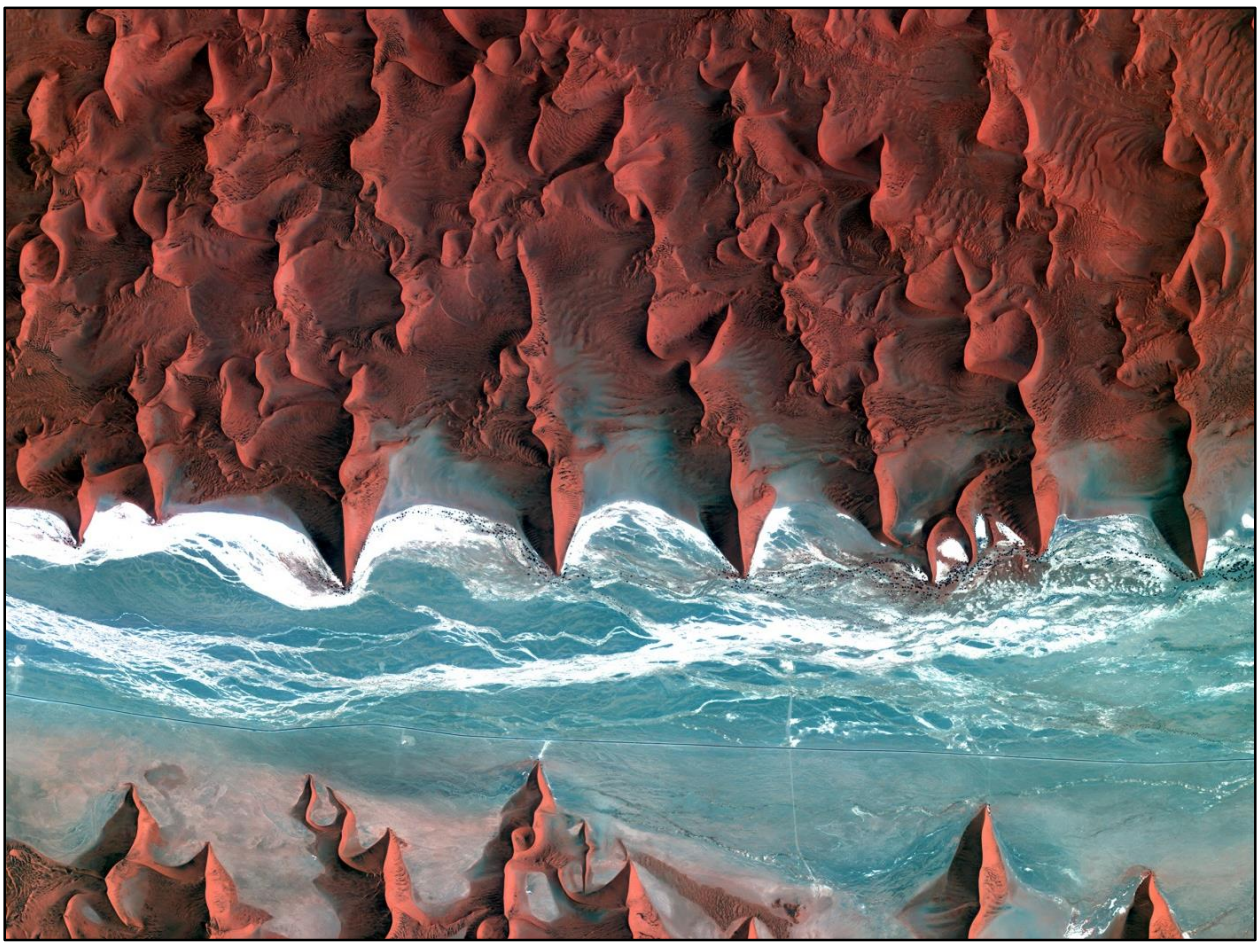
DEVELOP National Program

Health & Air Quality Project Proposals

Summer 2015



Proposals Snapshot

1. Los Angeles Health & Air Quality: Identifying Urban Emission Patterns in Los Angeles Using *In Situ* Observations from JPL's Megacities Carbon Project, NASA's OCO-2 and Terra satellite, and JAXA's GOSAT (JPL)
Objective: Provide the California Air Resources Board (CARB) with a survey of emissions data in the Los Angeles Megacity (LAM) region from both top-down and bottom-up approaches. The results from the JPL and Earth Networks in situ observational network will be analyzed alongside remotely sensed data, including NASA's OCO-2 satellite, MOPITT (Terra satellite) and CLARS (Mt. Wilson Observatory), to test the hypothesis of whether fossil fuel greenhouse gas (GHG) emissions can be observed from space.

2. Arizona Health & Air Quality: Enhancing Extreme Heat Intervention and Preparedness Activities in Maricopa County, Arizona with NASA Earth Observations (Langley)
Objective: Investigate how information regarding spatial variability in heat exposure in Maricopa County, Arizona, can improve extreme heat adaptation strategies. The public health benefits of the regional heat warning system and network of cooling centers could be improved with a more targeted approach toward identifying the most at-risk areas and populations.

3. Brazil-Venezuela Health & Air Quality: Earth Observation Identification of Rural Village Sites along the Brazil and Venezuela Border for Targeted River Blindness Disease Eradication (Goddard, Marshall & Wise County)
Objective: Assist the Carter Center in its mission to eradicate onchocerciasis (river blindness disease) in the Americas by the end of 2015. Through NASA and commercial remote sensing imagery, this project would create a methodology for identifying remote villages of the Yanomami people to support targeted eradication efforts.

Partners Snapshot

State Partners

- California Air Resources Board (End-User/Collaborator, POC: Abhilash Vijayan, Manager, Greenhouse Gas Technology & Field Testing Section)
- Arizona Department of Health Services (ADHS) (End-user/Partner/Boundary Organization, POC: Matthew Roach, Climate and Health Program Manager)

Federal Partners

- Goddard Space Flight Center (POC: Dr. Jim Tucker, Physical Scientist)
- SERVIR (POCs: Dan Irwin, Project Director & Kel Markert, Research Assistant)

NGO Partners

- Carter Center (End-User, POC: Dr. Frank Richards, Director, River Blindness Elimination Program)

Academic Partners

- Arizona State University, Environmental Remote Sensing and Informatics Lab (ERSL) (Partner, POC: Billie L. Turner II, Professor)
- Arizona State University, Center for Policy Informatics (CPI) (Partner POC: Erik W. Johnston, Associate Professor)

Project Proposals

1. Los Angeles Health & Air Quality (JPL)

Identifying Urban Emission Patterns in Los Angeles Using *In Situ* Observations from JPL's Megacities Carbon Project, NASA's OCO-2 and Terra satellite, and JAXA's GOSAT

Objective:

This project will provide the California Air Resources Board (CARB) with a survey of emissions data in the Los Angeles Megacity (LAM) region from both top-down and bottom-up approaches. The results from the JPL and Earth Networks *in situ* observational network will be analyzed alongside remotely sensed data, including NASA's OCO-2 satellite, MOPITT (Terra satellite) and CLARS (Mt. Wilson Observatory), to test the hypothesis of whether fossil fuel greenhouse gas (GHG) emissions can be observed from space.

Community Concern:

Quantifying greenhouse gas (GHG) emissions from cities is an important part of understanding anthropogenic impacts on climate. Cities produce about 75% of fossil fuel CO_2 emissions in < 3% of the Earth's land surface. Spatially concentrated emissions produce measurably elevated CO_2 mixing ratio, which can be monitored to determine the efficacy of current and future emissions control efforts, including the Global Warming Solutions Act (California Assembly Bill 32, 2006). Integrating urban CO_2 monitoring strategies with statewide inventories and fossil-fuel activity data validates the efficacy of CO_2 emissions mitigation. GHG-observing satellites allow space-based observation of emissions from large cities, but require validation using ground observations. The Megacities Carbon Project at JPL has an *in situ* surface network measuring GHGs in the Los Angeles Megacities. These observations can be used to explore the spatial and temporal patterns of GHG emissions, improve emissions inventories, and validate satellite measurements.

End-Users/Partners/Boundary Organizations:

California Air Resources Board (End-User/Collaborator, POC: Abhilash Vijayan, Manager, Greenhouse Gas Technology & Field Testing Section)

The California Air Resources Board (CARB) is a partner with JPL and several other institutions in the Megacities project. The POC for CARB, Abhilash Vijayan, has been contacted via email. He has expressed that, "as partners in the Megacities project, we are very much interested in supporting this effort." The project will incorporate data from CARB's emission inventories. The results of the project will be presented to CARB at the end of the term, and a report on the project's findings will also be made available to them. This project will serve as a starting point for similar collaborations between the Megacities project and CARB, and will benefit both parties by demonstrating how data exchange and comparison can be coupled with satellite observations to bring urban emissions into focus.

Decision Making Process:

The California Air Resources Board (CARB) has been charged by the state of California to enact the Global Warming Solutions Act (California's Assembly Bill 32 of 2006 [AB 32]). AB 32 mandates a 25% reduction in GHG emissions by 2020. The Greater Los Angeles area, or the L.A. Megacity (LAM), emits a significant fraction of California's GHG emissions, with 47% of California's population concentrated in 20% of the state's land area. Hence, emissions monitoring and verification efforts in Los Angeles are highly relevant for statewide emissions control efforts. In this project, participants will work with JPL scientists to develop products that link urban GHG observations to CARB's statewide emission inventories. Currently, *in situ* measurements and modeling are used to create emissions inventories. This project is the first step in using this data to

verify measurements from the newly-launched OCO-2 satellite. We anticipate this work will help CARB decide how to best monitor and verify statewide emissions using both on-the-ground networks and satellite data. In addition, improved emissions inventories inform policy decisions about emission reductions.

Earth Observations:

Platform	Sensor	Geophysical Parameter
OCO-2	OCO-2	CO_2 total column concentration
GOSAT	GOSAT	Methane and CO_2 total column concentration
Terra	MOPITT	CO total column and tropospheric column concentration
Mt. Wilson Observatory	CLARS	Methane and CO_2 "slant" column observation

NASA Earth Observations to be Highlighted:
OCO-2, launched July 2014, is expected to revolutionize global GHG concentration space-borne measurements. However, the data coming from the satellite needs to be validated using "ground-truth" measurements before it can be used for analyses or emissions quantification. The project advisors have access to data from OCO-2 during which it took targeted measurements of GHG over LAM. This data will be compared with *in situ* measurements of GHG in LAM made by JPL's Megacity project in 2014 through a city-wide, in situ observational network (15 sites in total, with continuous CO_2 measurements collected at roughly half). CO_2, CO, and methane fields from the CLARS facility on Mt. Wilson will also be considered in the evaluation of CO_2 and CO gradients and $FFCO_2$ estimates for the LAM. CO concentrations measured using the MOPITT sensor on the Terra satellite are of particular interest in this project because CO is a tracer for fossil fuels. A comparison of all of these datasets, along with CARB's statewide inventory, will demonstrate the capabilities of NASA Earth observations to aid in GHG monitoring.

Ancillary Datasets:

- CARB emission inventories
- LA Megacity project *in situ* data: observations include continuous measurements of CO_2, CH_4, and CO mole fractions, meteorological data and occasional flask samples for measurement of fossil fuel tracers (e.g. 14C) in collaboration with the National Oceanic and Atmospheric Administration.

Decision Support Tools & Analyses:

Proposed End Products	Decision Impacting	Current Partner Tool/Method
Emissions Map Series for Los Angeles Megacity	How *in situ* and satellite data can be incorporated into monitoring decisions	*In situ* data
Emissions Data Analysis	How *in situ* and satellite data can be incorporated into monitoring decisions	Currently, data sharing and analysis is done on a limited basis for case studies

Emissions Map Series for Los Angeles Megacity – Map of emissions data from several sources; sub-maps to include sectoral allocation of emission sources

Emissions Data Analysis – Comparison of the current CARB inventory with emissions constraints from field data, including ground-based measurements and remote sensing techniques

Project Details:
National Application Area Addressed: Health and Air Quality

Source of Project Idea: A former project advisor approached Ben Holt regarding this new project.

Advisors: Francesca Hopkins (JPL), Kristal Verhulst (JPL), Charles Miller (JPL)
# of Participants Requested: 3

Project Timeline: 1 Term: 2015 Summer
Study Location: Los Angeles, CA
Period being Studied: 2014 – Present; potential case study dates: Oct 7, 2014 and Jan 2, 2015

Previous Related DEVELOP Work:
Los Angeles Health and Air Quality: Detecting Policy Relevant Greenhouse Gas Emission Reduction Scenarios for Los Angeles Utilizing Current and Future Remote Sensing Capabilities - Summer 2012 (JPL)

Notes:
References

1. Duren, R., Miller, C., 2012, Measuring the carbon emissions of megacities, Nature Climate Change, 2, 8, 560-562, doi: 10.1038/nclimate1629
2. IEA World Energy Outlook 2008 Ch. 8, 179–193 (International Energy Agency, 2008).
3. Kort, E., et al., 2013, Surface observations for monitoring urban fossil fuel CO_2 emissions: Minimum site location requirements for the Los Angeles megacity, *J. Geophys. Res. Atmos.*, 118, 3, 1577-1584, doi:10.1002/jgrd.50135
4. Kort, E., et al., 2012, Space-based observations of megacity carbon dioxide, Geophys. Res. Letters, 39, 1.
5. Megacity Carbon Project Website and Data Portal: https://megacities.jpl.nasa.gov/portal/

2. Arizona Health & Air Quality (Langley)

Enhancing Extreme Heat Intervention and Preparedness Activities in Maricopa County, Arizona with NASA Earth Observations

Objective:
The project objective is to learn how information regarding spatial variability in heat exposure in Maricopa County, Arizona, can improve extreme heat adaptation strategies. The public health benefits of the regional heat warning system and network of cooling centers could be improved with a more targeted approach toward identifying the most at-risk areas and populations. Further, the heat mortality and morbidity reports prepared by county and state health agencies, which are a main source of data for local practitioners and researchers interested in improving heat resiliency efforts, give no explicit consideration to the role that spatial variability in temperature may play. The DEVELOP team can add this spatial perspective to the data to determine spatial factors that influence higher death rates. This project will create an extreme heat remote sensing climatology of Maricopa County that will subsequently be integrated into a participatory research process with end-users, partners, and boundary organizations to determine if and how spatial variability in temperature is relevant to customization of heat-health interventions.

Community Concern:
Extreme heat is a chronic health hazard in the hot desert climate of central Arizona and one that is projected to become more dangerous because of climate fluctuations and an aging population. The built environment is a potentially exacerbating contributor to heat-related

health risks as the urban form results in elevated nighttime and daily average temperatures compared with rural surroundings. This variability in environmental conditions interacts with demographical patterns to create a complex urban "riskscape" for heat-related health hazards. A variety of adaptation strategies are in place in Maricopa County, including a public heat warning system and a network of publicly-available cooling centers, but the provision of such services (e.g., warning message content, location of cooling centers) generally does not account for place-based variability in risk. A shared goal of public health practitioners and researchers in the region is to tailor service provision to the places and populations of greatest need to reduce preventable heat-related illnesses and deaths.

End-Users/Partners/Boundary Organizations:

Arizona Department of Health Services (ADHS) (End-user/Partner/Boundary Organization, POC: Matthew Roach, Climate and Health Program Manager)

Environmental Remote Sensing and Informatics Lab (ERSL) at Arizona State University (Partner, POC: Billie L. Turner II, Professor)

Center for Policy Informatics (CPI) at Arizona State University (Partner POC: Erik W. Johnston, Associate Professor)

ADHS coordinates the statewide heat safety task force (which Maricopa County Department of Public Health and Arizona State University are active participants in) and leads the state's participation in CDC's Building Resilience against Climate Effects initiative. ADHS can provide guidance throughout the project via in-person meetings with the researchers; decision support tools and project findings will be shared through statewide heat safety meetings. ERSL provides expertise and computational support for processing remote sensing products and creating visualization tools; David Hondula, the main science advisor for this project, regularly collaborates with multiple ERSL personnel and has access to ERSL facilities.
End-users who will be important to engage in the second project term include staff from the Phoenix Heat Relief Network and the Phoenix office of the National Weather Service.

Decision Making Process:

Project methodology and results will be communicated with decision-making entities for heat-health interventions in Phoenix including the National Weather Service Phoenix Forecast Office and the Phoenix Heat Relief Network. These organizations are responsible for coordination of the heat warning system and network of cooling centers, respectively.

The National Weather Service issues heat warning products to its entire service region based on meteorological observations at Phoenix Sky Harbor airport and forecaster expert opinion on the conditions that are most dangerous for human health. One message is broadcast to the entire service region. In some cases, this message is relayed by partnering agencies to specific end-users (e.g., a municipal health department specifically alerts the health sector of the heat warning). No remote sensing information data is currently used to customize the warnings based on spatial variability. The warning zone typically spans multiple counties across central and southern Arizona; Maricopa County alone spans more than 9,000 square miles and is the 14th-largest county in the United States. Temperatures—especially at night—can be highly variable within this large zone because of urban heat island effects and topography. Even the higher-resolution meteorological networks available in the greater Phoenix area (e.g., Maricopa County Flood Control District Stations: http://alert.fcd.maricopa.gov/alert/Google/v3/air.html) provide only a fraction of the coverage necessary for adequate representation of the temperature contrasts experienced by area residents.

The Phoenix Heat Relief Network emphasizes serving the homeless population and, as such, many facilities in the network are those already involved in the provision of other services to the

homeless (e.g., food banks, Salvation Army locations). The network configuration is thus based on the location of existing accessible resources and willing participants without explicit consideration of spatial risk patterns. No remote sensing products are used to evaluate network coverage or identify places most in need of new network members.

Earth Observations:

Platform	Sensor	Geophysical Parameter
Landsat 7 and 8	Enhanced Thematic Mapper Plus, Operational Land Manager, Thermal Infrared Sensor	Land Surface Temperature
Terra	MODIS, ASTER	Land Surface Temperature, Digital Elevation Model
Aqua	MODIS	Land Surface Temperature
Suomi NPP	VIIRS	Day/Night Band Reflectance

NASA Earth Observations to be Highlighted:
Surface temperature sensors onboard NASA spaceborne platforms provide continuous spatial coverage within urban areas that complements ground-based observations of air temperature available at fixed points. Satellite imagery is widely used in assessment of the urban heat island but there is little evidence of applications to extreme heat adaptation strategies in the scientific literature. Analysis will include the compilation of Landsat 7, Landsat 8, ASTER, and MODIS images representative of extreme heat days and nights in Maricopa County, processing of original imagery to surface temperature with appropriate calibration parameters, and aggregation of temperature patterns to jurisdictions of relevance for public health practitioners (e.g., postal codes, census tracts). ASTER DEM data will be added to visualize the spatial variation in heat with elevation. Suomi NPP VIIRS will be used as a proxy for population through the use of the Day/Night Band reflectance.

Ancillary Datasets:

- Ground-based meteorological observations from AZMet and Weather Underground
- Locations of Heat Relief Network cooling centers from Maricopa County Health Department
- Geospatial boundary files and demographic indicators from ASU-GIS spatial data repository and U.S. Census/TIGER
- Maricopa County heat vulnerability maps from ASU Urban Vulnerability to Climate Change project
- Maps of spatial variability in heat-health outcomes from Maricopa County Department of Health and D. Hondula's dissertation research
- Responses from summer 2014 cooling center evaluation conducted by MCDPH, ASU, and ADHS, including facility manager interviews, visitor surveys, and facility observations
- Teleconnection Indices from NOAA National Centers for Environmental Information (NCEI) (Formerly National Climatic Data Centers).
- National Land Cover Dataset 2011 impervious surface estimates

Decision Support Tools & Analyses:

Proposed End Products	Decision Impacting	Current Partner Tool/Method
1. Remote Sensing Climatology of Maricopa County Surface Temperatures on Extreme Heat Days and Nights	Examples of impacted decision include: Locating candidate communities for tailored heat	Examples of current partner tools/methods include: Warning system – uniform application of strategy across service region;

2. Maps of correlations with teleconnection indices 3. Maps of heat duration and recurrence (including definitions based on temperature and temperature-humidity metrics) 4. Revised heat vulnerability maps	warning messaging/triggers Selecting site locations of Phoenix Heat Relief Network cooling centers Seasonal heat preparedness, research concerning drivers of local temperature change County and state health department vulnerability mapping County and state health department research identifying vulnerable communities (serving as basis for subsequent interventions)	Cooling centers – Network comprised of volunteering facilities Little evidence of seasonal outlooks being incorporated into awareness campaigns at present Vegetation cover and urban NLCD fraction are primarily used at proxy variables for temperature Other variables commonly used as proxy variables for temperature in vulnerability index calculation, use of remote sensing products highly limited (e.g., 1 image)

Remote Sensing Climatology of Maricopa County Surface Temperatures on Extreme Heat Days and Nights – The team will assemble a set of remotely sensed images of surface temperature patterns on hot days and nights. Where possible, comparisons will be made with ground-based observations to validate representativeness of surface temperature as a proxy variable for spatial variability in heat stress using spatial regression techniques. Separate maps will be created for daytime and nighttime conditions and daily mean, as well as a complementing set of maps assessing inter-image variability in temperature patterns.

Maps of correlations with teleconnection indices – The teams will create maps that show the correlation values between MODIS LST climatology and teleconnection indices. This will provide a spatial perspective of how the variability in temperatures across this large county can vary with larger-scale atmospheric patterns.

Maps of heat duration and recurrence – This will two separate maps showing how long (durations) heat stress occurs, and the recurrence interval of extreme heat days throughout the large study region. Both maps will be based on MODIS LST climatology and *in situ* measurements.

Revised heat vulnerability map – This map will show the climatological risk across the Maricopa county area using an index calculated from humidity, temperature, duration of high heat, population, and distance from cooling stations.

Project Details:

National Application Areas Addressed: Health & Air Quality, Disasters, Climate

Source of Project Idea: The project builds on a number of related initiatives at the Maricopa County Department of Public Health and Arizona State University assessing spatial variability in sensitivity to heat, evaluating utilization and accessibility patterns in the Phoenix Heat Relief Network, and enhancing heat warning products for suitability with the regional climate. This

project idea emerged from conversations between the proposed advisors regarding opportunities for improving these efforts and public health practice related to extreme heat.

Advisors: Kate Goodin (Maricopa County Department of Public Health), Dave Hondula (Arizona State University), Dr. Kenton Ross (NASA DEVELOP National Program)
# of Participants Requested: 4 (Three at Langley and one in Maricopa County [at MCDPH-ASU])

Project Timeline: 2 terms: 2015 Summer to 2015 Fall
Study Location: Maricopa County, Arizona
Period being Studied: January 2006 – December 2014 (the period for which data are available from MCDPH's heat mortality surveillance program)

Multi-Term Objectives:

- **Term 1 (Proposed Term)** – Create library of extreme heat day remote sensing imagery of Maricopa County, AZ from 2006–present from Landsat 7 ETM+, Landsat 8 TIRS, and Terra and Aqua MODIS data; generate maps of representative surface temperature patterns and variability for day and night conditions; generate maps of spatial correlation values between teleconnection indices and heat wave magnitude and duration; compile ancillary data sets.
- **Term 2** –The second term will emphasize stakeholder engagement. In the first month, the research team will create and host a stakeholder workshop/design session in which the results from Term 1 are shared and ideas for their utility in improving heat interventions developed. DEVELOP participants and NASA staff will contribute to the development of the stakeholder workshop but MCDPH and ASU personnel will lead collection of qualitative data at the workshop and subsequent analysis such that only those personnel require IRB approval. The team will then develop a prototype for a real-time or near real-time product, using MODIS LST, which could improve heat intervention activities in the region (as conceptualized at the first workshop). This proof of concept will be shared at a second workshop held at the end of the second term. If the concept gains momentum, the team could work in subsequent terms for on-boarding the solution for the 2016 heat season. In the second term, results from Term #1 will also be incorporated into vulnerability mapping techniques employed by the state health department and other researchers and a comparison of the "enhanced" vulnerability products that more explicitly account for temperature (and temperature variability across space and time) will be developed.

3. Brazil-Venezuela Health & Air Quality (Goddard, Marshall & Wise)

Earth Observation Identification of Rural Village Sites along the Brazil and Venezuela Border for Targeted River Blindness Disease Eradication

Project Objective:
This project aims to assist the Carter Center in its mission to eradicate onchocerciasis (river blindness disease) in the Americas by the end of 2015. Through NASA and commercial remote sensing imagery, this project would create a methodology for identifying remote villages of the Yanomami people to support targeted eradication efforts.

Community Concern:
Recently, the Carter Center reached out to NASA for help with a pressing public health challenge: river blindness disease (Onchocerciasis) in the Americas. The Carter Center is currently working with a mandate from the World Health Organization to coordinate with public health authorities to eradicate river blindness in the Americas by the end of 2015. While working

to eliminate cases of the disease at multiple locations in South and Central America, difficulty for the program occurs in reaching the Yanomami people living in a remote region on the border between Brazil and Venezuela. Specifically, the Carter Center River Blindness Program is looking for aid in finding transitory single-clearing villages called malocas in the hardest-to-reach areas of Yanomami territory. The Carter Center is especially interested in help from NASA with imagery and data processing techniques that could help in identification of malocas that typically appear as clearings on the order of 100 meters across in otherwise trackless rainforest. In the past, the Carter Center and others that have sought to identify village locations have relied on aerial surveys and limited acquisitions of high resolution commercial satellite, but limited resources have prevented either of those techniques being applied with sufficient regional coverage and temporal frequency.

Decision Making Process:
The Carter Center is currently working with a mandate from the World Health Organization to coordinate with public health authorities to eradicate river blindness in the Americas by the end of 2015, and has nearly reached the goal. Difficulty lies in reaching the Yanomami people living in a remote region on the border between Brazil and Venezuela. The Carter Center River Blindness Program is trying to identify transitory single-clearing villages called malocas in the hardest-to-reach areas of Yanomami territory so that they can send medical professionals in by helicopter to offer remedial support. In the past, the Carter Center had purchased high-res imagery and was supported by the University of South Florida in attempting to identify the villages, but the endeavor was not fully successful in providing a replicable methodology.

Earth Observations:

Platform	Sensor	Geophysical Parameter
Landsat 8	OLI/TIRS	Land cover
Terra	ASTER	Land cover, DEM
Suomi NPP	VIIRS	Night lights
WorldView-1 & 2, GeoEye-2, QuickBird	Digital Globe	Land cover

NASA Earth Observations to be Highlighted:
Landsat 8, ASTER, and VIIRS data layers would be combined to find potential village locations in the rainforest region. Change detections of land cover classifications identifying the migratory patterns and locations of the Yanomami would then be checked against high-res commercial datasets for accuracy.

Ancillary Datasets:
- High resolution Digital Globe data (source: Dr. Tucker, GSFC through NGA data-share)
- Locations of known Yanomami villages (source: Carter Center and Brazil/Venezuela governments)
- Land cover analyses in the region (source: TBD)
- Previously conducted project results & methodologies (source: University of South Florida)

Study Location: Border region between Venezuela & Brazil
Study Period: 2012 - 2015

Decision Support Tools & Analyses:

Proposed End Products	Decision Impacting	Current Partner Tool/Method
Potential Yanomami Village Location Map	Where to target disease eradication efforts	Previous USF analysis; Helicopter field surveys
Unsupervised Land	Understanding what analyses should	Limited - previous USF

Classifications	be included in the potential location map	analysis
Land Cover Change Detections	Understanding what analyses should be included in the potential location map	N/A
Night Lights Map	Understanding what analyses should be included in the potential location map	N/A
Geodatabase	Where to get useful data for locating villages	N/A
Certainty Analysis	Whether or not the methodology can detect villages	N/A
Scaling Methodology & Tutorial	How to take the methodology and scale it up to the full region encompassing Yanomami villages	N/A

Potential Yanomami Village Location Map – This product utilizes multiple layers from all EO datasets listed to combine land classifications, change detections, night lights, and other appropriate datasets, into a map that identifies potential locations of Yanomami villages.

Unsupervised Land Classifications - Assess greenness of canopy cover to identify locations that have seen anthropogenic impact.

Land Cover Change Detections - Assess change over time in the region to identify the migratory patterns and locations of the Yanomami for identification of villages.

Night Lights Map - Use VIIRS night lights to see if there are any increases in specific areas that could raise certainty of human activity.

Geodatabase - Identify available data, collect it into a single repository and pre-process it into an easily analyzed geodatabase. Data will include commercial imagery available through the National Geo-intelligence Agency, NASA Earth observations and other ancillary datasets.

Certainty Analysis - Apply the methodology to known village locations for improved certainty.

Scaling Methodology & Tutorial - Assist the Carter Center and their stakeholders in scaling methods to the level necessary to realize their River Blindness eradication goals by the end of 2015.