Mentor Projects for Summer 2020

**Project ID:** Anderson-Disasters-UAH/NASA-2020  
**Title:** Exploring how satellite data can inform early action to reduce the impacts of floods & landslides  
**Mentor:** Mr. Eric Anderson, UAH Earth System Science Center / NASA SERVIR

SERVIR is a joint program led by NASA and the US Agency for International Development (USAID) that promotes the use of Earth observations for environmental decision-making in Eastern and Western Africa, South and Southeast Asia, and South America. Many of these regions are exposed to landslides and floods, and one goal of SERVIR is to help increase communities’ preparedness for and resilience to disasters. Recently, SERVIR has been collaborating with the Red Cross Red Crescent movement to further understand how the humanitarian sector can use satellite data and forecasts to reduce the cost and impact of disasters.

Using NASA and other satellite assets, the student will explore how existing disaster inventories and archived flood forecasts could have informed humanitarian early action. The vision is a reduction of flood and landslide-induced losses. At the end of the project, the student will have contributed to a more robust description of the strengths and weaknesses of existing scientific and decision-making systems toward one specific disaster risk reduction project in a SERVIR country. This project offers the student the chance to collaborate with scientists and practitioners from NASA centers and international technical organizations in SERVIR regions, as well as with experts in the Red Cross Red Crescent movement.

Imagining new ways to link NASA and humanitarian work (left) and a representation of improving rainfall estimates for flood forecasting in Cambodia (right)
North Alabama is known as a tornado "hot spot" due to a number of high-profile tornado events over the years (such as the 27 April 2011 "Super-Outbreak" and 28 April 2014 outbreak). Despite these challenges, much of the area still continues to experience rapid economic growth and expansion; according to the U.S. Census Bureau, the population of Madison County, Alabama has grown by more than 30% since 2000. This growth is greatly expanding the area and population that could potentially be affected by tornadoes (often called an "expanding bulls-eye"). The National Weather Service forecast office in Huntsville is interested in understanding this evolving vulnerability across northern Alabama better, so outreach, education, and communication can be improved before, during, and after severe weather events. To that end, this project will leverage GIS and remote sensing data (e.g., historical tornado tracks, satellite imagery, land use, population density) to assess changing tornado vulnerability. Students can also expect to spend some limited time working with NWS meteorologists during routine and impact weather to better understand NWS operations.
For many years, satellite observations have suggested that the region around the Sierras de Córdoba (SDC) of Argentina produce some of the most intense thunderstorms in the world with respect to the frequency of large hail, high storm tops and extreme relámpago or lightning. During the National Science Foundation (NSF) funded RELAMPAGO (Remote sensing of Electrification, Lightning, And Mesoscale/microscale Processes with Adaptive Ground Observations) field project, a wide variety of meteorological instruments were deployed in and around Córdoba, Argentina and the SDC during November and December 2018 to study these storms, including multiple radars, mobile sounding teams, and networks of lightning sensors. The initial development and rapid growth of several severe storms were observed during RELAMPAGO, including the supercell pictured with RMA1 radar reflectivity (dBZ) on 10 November 2018 during Intensive Observation Period #04 (IOP04). The supercell was observed by three Center for Severe Weather Research (CSWR) Doppler on Wheels (DOW) mobile X-band radars in addition to an operational Córdoba (RMA1) C-band radar and the Colorado State University (CSU) C-band research radar. Large hail was collected at the ground. A possible tornado debris signature (TDS) and a low-level rotational velocity couplet were observed in the DOW polarimetric and Doppler measurements. Elevated lightning flash rates were observed by the National Aeronautics and Space Administration (NASA) Lightning Mapping Array (LMA) and the UAH Córdoba Area Marx Meter Array (CAMMA). Several mobile sounding teams documented the pre-convective environment. The overall goal of the project is to use multiple Doppler/polarimetric radars to investigate the structure and severe storm signatures (e.g., hail and possible tornado) of a unique supercell from the Southern Hemisphere. Opportunities to study the meteorological environment supporting the supercell and its lightning properties also exist. Familiarity with or a desire to learn the LINUX computing environment and Python programming tools is desirable.
Project ID: Cherrington-LiDAR-UAH/NASA-2020
Title: Analysis of LiDAR data for northern Alabama
Mentor: Emil A. Cherrington, Ph.D.
Earth System Science Center, the University of Alabama in Huntsville
SERVIR Science Coordination Office, ST11, NASA Marshall Space Flight Center

A type of active remote sensing involving the use of lasers, Light Detection And Ranging (LiDAR) has been used for studies ranging from topographic surveying to forest inventories to ecosystem mapping to biomass estimation. In 2011 and 2018, airborne LiDAR data was acquired over Huntsville, including over the University of Alabama in Huntsville (UAH) campus (see Figure). Recently, Margaret Klug, a UAH graduate student completed her master’s degree studies in examining how LiDAR could be used for estimating the biomass of the trees on the UAH campus. The airborne LiDAR data used by Klug have recently been complemented by the release of spaceborne LiDAR data from the ATLAS sensor on NASA’s ICESat-2 satellite, and from the Global Ecosystem Dynamics Investigation (GEDI) instrument on the International Space Station (ISS). One key area of interest is how the data from GEDI and ICESat-2’s ATLAS essentially match up with ground truth data.

Figure: LiDAR imagery of the UAH campus, including the National Space Science & Technology Center (NSSTC), in the bottom right; visualization generated using https://plas.io.
Proposal ID: Griffin-Lidar-Ecology-UAH/NASA-2020
Title: Tropical Forest Ecology and Ancient Maya Archaeology with Airborne LiDAR and Hyperspectral Satellite Data
Mentor: Dr. Robert Griffin, UAH Atmospheric & Earth Science Department

Example G-LiHT LiDAR-derived imagery showing topographic relief in a digital elevation model, along with the remains of ancient settlements and agricultural areas.

The Maya Biosphere Reserve is an expansive and densely forested natural reserve in northern Guatemala, with a considerable amount of vegetative biodiversity and ancient Maya archaeological ruins. Recent NASA missions such as Goddard’s LiDAR, Hyperspectral and Thermal Imager (G-LiHT) and NASA’s Global Ecosystem Dynamics Investigation (GEDI), have Light Detection and Ranging (LiDAR) capabilities that make it possible to create high resolution 3-D models of forest structure and underlying topography. G-LiHT also takes thermal measurements that can recognize surface temperature and moisture stress. Hyperspectral data from the DESIS hyperspectral imager further allows us to understand soil moisture, vegetation health, and to distinguish different forest types. Students will have the opportunity to apply these cutting edge data to inventory the diverse vegetative communities in the reserve, as well as to identify ancient Maya archaeological features such as house mounds using LiDAR’s ability to penetrate dense forest canopies. Students will learn to employ GIS (geographic information systems), and image processing applications for processing LiDAR and hyperspectral data. Complementing these data sources with optical data made freely available through the Google Earth Engine (GEE) platform, such as NASA’s Landsat 8 Operational Land Imager (OLI) and the European Space Agency’s (ESA) Sentinel 2 Multispectral Sensing Imager (MSI), will enhance the student’s understanding of the vegetative communities they are studying.
Project ID: Lang-AMPR-NASA-2020
Title: Analysis of airborne microwave radiometer observations from field campaigns
Mentor: Dr. Timothy Lang, NASA Marshall Space Flight Center

The Advanced Microwave Precipitation Radiometer (AMPR), which passively observes microwave brightness temperatures in four different frequencies, is flying in two field campaigns in 2019-2020. In August-October 2019, the instrument flew on the NASA P-3B aircraft as part of the Cloud, Aerosol and Monsoon Processes Philippines Experiment (CAMP²Ex), gathering ~140 hours of science observations of tropical maritime convective clouds in polluted and clean environments (Fig. 1). In January-February 2020, the instrument will fly on the NASA ER-2 high-altitude aircraft as part of the Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms (IMPACTS) field campaign, targeting snowbands in major storms in the northeastern and central United States.

This internship will provide a unique opportunity to get exposed to NASA airborne science, instruments, and datasets. The student will focus on AMPR data quality control and analysis from one or both of the above field campaigns. The intern will help evaluate and improve the quality of these unique airborne radiometer datasets, and will assist with the retrieval of important geophysical information such as precipitation, cloud ice and liquid water, atmospheric water vapor, and near-surface wind speed over the ocean. Comparison to observations from other airborne instruments is also possible. Finally, as part of these activities, the student would have an opportunity to get involved in laboratory-based testing of AMPR.

Figure: Brightness temperatures on a geolocated swath from the 37-GHz (B) channel of AMPR, for a portion of a CAMP²Ex flight on 29-30 August 2019 near Palawan, Philippines.
NASA SPoRT (Short-term Prediction Research and Transition Center) has been providing National Weather Service (NWS) forecasters with gridded rain rate estimates from NASA GPM’s IMERG Level 3 product since shortly after the core GPM satellite launched in 2014. Rain rate estimates from space-borne instrumentation assist forecasters by providing observations in regions that are “data void” for ground-based sensors, e.g., where radars are beam-blocked by terrain, where gauge data is sparse, and over oceans where few observations are taken. A new satellite mission, called TROPICS, is expected to launch in 2020. In its capacity as an Early Adopter organization, NASA SPoRT proposes to use L2b maximum sustained wind estimates from TROPICS in conjunction with IMERG rain rate estimates to provide observations to forecasters of tropical systems that may cause wind damage and flooding to coastal Weather Forecast Office County Warning Areas (WFO CWAs). The student will assist in developing visualizations of the datasets for experimental use in operations, with a focus on data being quickly and easily interpreted. Proxy datasets will be used if TROPICS data are unavailable. The student will help determine if wind and heavy rain threats as identified by TROPICS and IMERG are temporally and spatially relevant for potential operational use. To this end, the student will help compare the wind and rain data to surface observations where possible (e.g., using wind measurements and gauges onshore to validate near-shore estimates). These satellite observations could provide additional lead time for high impact weather events that include heavy rain and strong winds and assisting the NWS mission in protecting life and property in high impact weather events. The student will learn to access, plot, and interpret scientific datasets, such as those freely available from NASA, and will gain experience in transitioning applied scientific research to operational end users.
Project ID: Mecikalski-GOESR-UAH-2020
Title: Monitoring and Tracking Growing Clouds in 1-min GOES-16/-17 Imagery
Mentor: Dr. John Mecikalski, Chair Atmospheric and Earth Science Department

With the advent of 30-second and 1-minute resolution visible and infrared imagery from GOES-16 and GOES-17, a considerable amount of otherwise hidden cloud information and processes can now be seen, which were under-sampled in older 15-minute resolution data. The plan for this project will be to analyze GOES-16/-17 datasets over actively growing convective clouds and storms (Fig. 1), in a manner that shows phenomena such as rainfall that can be compared to radar datasets. Typically, radar observations depict precipitation and winds, while satellite imagery helps instead to characterize the updrafts within the clouds. Combined, use of radar and satellite datasets help to correlate locations of stronger storms and severe weather, whereas very rapid 1-3 minute changes in cloud features observed in satellite imagery can help forecasters predict forthcoming severe weather, or identify severe weather where radar data are unavailable (e.g., over oceans, in remote land regions). For this project, the incumbent will perform the following analysis: (1) choose a region of interest over which 30-second or 1-minute resolution GOES-16/-17 imagery have been collected, (2) download key visible and infrared datasets for day(s) of interest from the NOAA CLASS archive, (3) visualize the imagery in a common visualization program (e.g., McIDAS, IDV), (4) form analysis methods to collect infrared temperature and temperature trend information for growing clouds, and/or measure cloud motions for convective cloud features, (5) develop a database of cloud growth and/or cloud motion information to understand an evolving weather or storm phenomena in relationship to radar data, (6) draw conclusions and present an analysis of an event, highlighting the unique information that is gained when 30-sec/1-min data were analyzed, versus only 5- or 15-minute data.

Figure 1: True color imagery formed from 500-meter resolution GOES-16 red-green-blue channel imagery for 1956 UTC on 9 September 2019. White areas are cumulus and cumulonimbus clouds.
Project ID: Newchurch-RO3QET/PANDORA-UAH-2020
Title: PANDORA systems integration into a groundbreaking research platform
Mentor: Dr. Michael J. Newchurch, UAH Atmospheric & Earth Science Department
Ms. Paula Tucker, UAH Atmospheric & Earth Science Department

Ozone within the boundary layer (BL) of the lower troposphere has numerous consequences on the environment, which in turn influences the respiratory system of all mammals, and plants. Here at UAH the atmospheric chemistry program studies not only the ozone in the troposphere and stratosphere, but contributes significantly to satellite validation, air quality monitoring, and ozone transport within wildfire plumes. The Rocket City Ozone Quality Evaluation in the Troposphere (RO3QET) vehicle is the newest edition to the UAH Atmospheric Departments fleet of research vehicles. The vehicle will house one of seven Tropospheric Ozone LIDAR Network (TOLNet) LIDAR’s in conjunction with numerous atmospheric monitoring platforms from various institutions. One such platform will be the NASA PANDORA spectrometer instrument. This instrument is part of the Pandonia Global Network, which uses the science of the ground based radiation to measure trace gases such as ozone, nitrogen dioxide and formaldehyde in the atmosphere. This REU project will integrate the PANDORA instrument into the mobile truck platform. Specific objectives will include, but are not limited to: Learning operational limitations of the instrument; Integrating the instrument into the existing network of the mobile platform; Comparative analysis to satellite and ozonesonde retrievals; assist in deploying ozonesonde balloon systems. If chosen the student will gain valuable knowledge of various ways of atmospheric monitoring, data analysis, and hands on experience of system integration.
Project ID: Nair-Lidar/Vegetation-UAF-2020
Title: Remote Sensing of Vegetation Vertical Structure Using UAS Lidar
Mentor: Dr. Udaysankar Nair, UAF Atmospheric & Earth Science Department

Mapping of vertical structure of vegetation is important for ecosystem studies, surveying storm damage and for forestry applications. Lidar on an unmanned aerial system (UAS) is an effective method for mapping vegetation vertical structure. The proposed project will explore the utility of Lidar on an UAS platform for mapping vegetation vertical structure. Lidar data can be used to derive shape of vegetation canopy, which can used as input to models used for studying micrometeorology within forest canopies. Lidar can also be used to survey plots before and after land clearing and used to conduct analysis of changes in biomass. When combined with hyperspectral imaging, Lidar observations can be used to determine fuel loads in forest canopies. This project proposes to interface a low-cost Velodyne Puck (VLP16) with a data acquisition system and install it on a Matrice 600 UAS platform. This system will then be used to collect observations over multiple sites. The feasibility of utilizing this system for damage surveys and forestry applications will be explored.
Project ID: Pour-Biazar-GLM-LNOx-UAH/NASA-2020
Title: Estimating Lightning-Generated Nitrogen Oxides (LNOx) from Geostationary Satellite Observations
Mentor: Dr. Arastoo Pour-Biazar, UAH Earth System Science Center

Observing lightning from space is cool and exiting. It also has significant applications. Lightning constitutes a significant source of nitrogen oxides (NOx=NO+NO2) in the middle and upper troposphere and plays an important role in tropospheric ozone production. Lightning-generated NOx (LNOx) is emitted over a deep tropospheric column. Due to large concentrated number of lightning flashes in the storms, LNOx has significant impact on the background tropospheric chemical composition. For example, a summertime lightning event resulted in 28 ppb mid-tropospheric ozone enhancement over Huntsville, Alabama. With the data available from the Geostationary Lightning Mapper (GLM) onboard Geostationary Operational Environmental Satellite (GOES), near-realtime estimates of LNOx is now a possibility.

In this project, the student will employ a new technique for estimating LNOx based on observed lightning energetics provided by GLM. A methodology will be introduced for directly estimating LNOx, on a flash-by-flash basis, from the observed cloud-top lightning optical energy detected from satellite lightning imagers. The student will be working with NASA and UAH scientists to realize the impact of LNOx estimates on atmospheric composition using a state-of-the-science air quality model. In addition to enhancing the student’s technical knowledge, this project will expose the student to a professional research setting and will signify the value of teamwork.
Project ID: Wade-VORTEXSE-UAH-2020  
Title: Improved Understanding of Tornadic Quasi-Linear Convection Systems in the Southeastern U.S.  
Mentor: Mr. Ryan Wade, UAH Atmospheric & Earth Science Dept / SWIRLL  
Co-Mentor: Dr. Todd Murphy, Univ. of Louisiana Monroe, Atmos. Science  
Co-Mentor: Mr. Preston Pangle, UAH Atmospheric & Earth Science Dept / SWIRLL

A significant number of tornado events in the Southeastern U.S. and Tennessee Valley occur during the cool season (Nov – Mar) embedded in quasi-linear convective systems (QLCSs). Knowledge and direct detection of the fast-evolving tornadoes is currently quite sparse, and thus is the primary focus of the on-going NOAA-funded Verifications Of Rotation in Tornadoes Experiment – SouthEast (VORTEX-SE), and a proposed 2021 multi-agency, multi-university NSF field campaign in which the UAH SWIRLL facility will serve as the base of operations. Understanding the interaction between QLCSs and the rapidly evolving, highly variable boundary layer (BL) atmospheric environment in real-time is critical to improve forecasts and direct radar detection of QLCS tornadoes. In order to prepare for the upcoming NSF field campaign in 2021, there is a need to develop a radar, mesoscale, and synoptic climatology from data collected during the VORTEX-SE field program thus far broken down in to specific sub-regions across the Deep South. Specific work objectives for the student include 1) development of a sounding database of QLCS sounding data from both balloon data, high resolution models, and remote sensing profiles, 2) creation of a radar climatology of QLCS tornadoes in VORTEX-SE project domain, 3) compiling a climatology of severe weather parameters from the VORTEX-SE sounding database.