Office of Geographic Information Systems & Remote Sensing

Student GIS and Remote Sensing Poster Competition

April 8, 2016 | 1:00 - 5:00 pm
Virginia Tech, Newman Library Multipurpose Room (first floor)

Graduate Poster Session

1.

Quantifying Volumetric Fluctuations in Tropical Lakes and Reservoirs Using Satellite Remote Sensing

Tyler Keys and Durelle Scott

Lakes and reservoirs play an integral role in water resources management by storing large quantities of water commonly used for irrigation, hydroelectric power, water supply, and flood mitigation. Knowing the exact quantity of stored water and necessary water for each of these usages is a critical component of sustainable water resources management. However, limited amounts of hydrologic data in developing nations, most of which are located in the tropics, hinders the accurate monitoring of water storage and allocation. Recent improvements in remote sensing have greatly enhanced the ability to calculate volumetric fluctuations of lakes and reservoirs at given points through time but are limited by temporal resolution as well as the computational time required for image processing. This study utilizes high temporal resolution MODIS imagery in conjunction with satellite altimetry from three different altimetry databases to estimate lake and reservoir volumetric fluctuations at eight day intervals. The study specifically examines three large lakes and reservoirs: Balbina Reservoir in the Amazon River Basin, Lake Tana in the Nile River Basin, and Tonle Sap Lake in the Mekong River Basin. Altimetry-based water level estimations are validated by in situ water level data from monitoring stations while surface area and volume estimations are validated by bathymetric maps with corresponding stage-area and stage-volume relationships. Results indicate that both remotely sensed water levels and surface areas agree well with in situ measurements, supporting the appropriateness of this methodology.

2.

Implementation of a Mobile GIS Data Collection Framework for Watershed Master Planning

Paul Bender, Marcus Aguilar, and Dr. Randy Dymond

The Civil & Environmental Engineering Department at Virginia Tech (VTCEE) has been assisting the City of Roanoke in the stormwater planning process for several years due to the City's need to address regulatory pollution reduction goals. The City and VTCEE worked together to draft a first, prototype watershed master plan for Lick Run which will serve as a comprehensive management plan for water quality and quantity problems. In order to characterize Lick Run's current condition and understand the drainage patterns of the watershed, it was critical to verify the location and connections of the stormwater infrastructure network. City stormwater, engineering, and GIS personnel worked with VTCEE to develop a workflow leveraging the ArcGIS Online and Collector environments to enable field crews to survey infrastructure in the field and update the City's stormwater ArcSDE database on the fly. VTCEE provided training for survey crews on the new workflow, and performed quality control on the data at the start and nearing the end of data collection. During final quality control, as-built plans and field verification were used to ascertain drainage patterns in difficult problem areas. The final dataset was used to describe the watershed drainage patterns, the perennial streams, and the impacts of urbanization which altered the stream channel and changed the hydrology of the watershed. The information gained from the updated drainage network allowed VTCEE researchers to develop policy and programs in the watershed and to locate potential sites for stream restoration, stormwater control measure retrofits, and infiltration best management practices.

3.

Potential Application of Seasonal Vegetation Indices and Land Surface Temperature in Drought Monitoring

Hoa Tran

Drought is an insidious hazard of nature relates to period of abnormally precipitation. Drought can occur in every part of the world, even humid regions. This phenomenon causes the disruption of ecological and economic systems. Furthermore, drought also encourages desertification and land degradation, which are the most vulnerable processes in arid and semi-arid areas. Meteorological data does work to determine drought period, but for monitoring vulnerability of drought, they are not fully sufficient, especially in the remote areas that there is lack of robust data collection. Up-to-date information and *in situ* observation from satellite imagery can be considered as a comprehensive method to forecast, monitor and evaluate drought and climatic conditions. While vegetation health is one of direct indicators of drought, land surface temperature is a helpful and supportive index to determine vegetation stress of water

and temperature distribution during drought periods. This research investigates in multiple-temporal Landsat imagery to retrieve Land Surface Temperature, and Seasonal Normalized Difference Vegetation Index (NDVI). Those indexes will be applied in calculate Vegetation Condition Index (VCI). Finally, a pixel based pixel linear regression algorithm between vegetation and temperature indexes will be established for identifying Vegetation Health Index (VHI) as proxy data to monitor drought, map its spatial distribution, and classify drought severity in Tuy Phong district, Binh Thuan, Vietnam.

4.

An ambulance resource scheduling technique for optimizing response times and areal coverage

David Goldberg and Patricia Garvey

Ambulances are a critical class of Emergency Medical Services (EMS) for ensuring public health and safety. However, ambulance response times vary significantly across geographic areas, and many localities lament experiencing lackluster service. Furthermore, while accepted standards for ambulance response times also vary geographically, the most common standard is a response time of 8 minutes or fewer achieved in at least 90 percent of instances. However, this standard is rarely met: ambulance response times are increasing over time in many areas, and response times for some 911 calls have exceeded 30 minutes.

We propose a technique for employing spatial analysis, computer simulation, and mathematical modeling in concert to optimize ambulance resource scheduling. By geocoding public 911 call data from Baltimore, Maryland, we construct a simulation model for ambulance requests, accounting for peak and off-peak demand and for spatial variation. Furthermore, we perform an analysis of Baltimore road networks to estimate the distribution of ambulance drive times across geographic areas. Utilizing this information, we construct a mathematical model to inform decision making on ambulance resource scheduling. Subject to constraints on paramedic and ambulance availability, we then compare response time and areal coverage yields across schedule configurations. Finally, we present novel insights as to optimal schedule configurations and trade-offs between various solutions, allowing decision makers to understand how best to improve EMS outcomes. Our technique is widely applicable, and decision makers from various regions may implement our methodology to improve local EMS schemes.

5.

Modeling Eastern Virginia Wetland Change with Spatially Explicit Markov Chains

Austin Cooner

Coastal wetlands provide unique habitats and numerous ecosystem services. However they have come under increased stress due to sea level rise and human development.

Modeling the rate of wetland disappearance is important for mitigating and preventing the loss of these fragile ecosystems. Markov chain models (MCM), often used for their simplicity, are land cover change predictors for bitemporal periods, but have the drawback of ignoring spatial cues and only approximating first order change. A spatially explicit Markov chain model (SEMCM) was developed and implemented on post classified multitemporal Landsat imagery to improve the estimations of future wetland loss near Mockhorn Island State Wildlife Refuge, Virginia.

6.

Headwater Stream Length Dynamics Across a Physiographic Gradient in the Appalachian Highlands

Carrie Jensen and Kevin J. McGuire

Headwaters are dynamic drainage networks that regularly expand and contract in length following storms, seasonally, and from year to year. The extent and frequency of headwater wetting and drying are not well understood across different geographic regions, precluding effective management of temporary streams to maintain ecological function and protect downstream water quality for human consumption. This project characterizes changes in wetted stream length in forested headwater catchments spanning four physiographic provinces of the Appalachian Highlands: the New England, Valley and Ridge, Blue Ridge, and Appalachian Plateau. The streams of three catchments (<70 ha) in each study area are mapped six times with a Global Positioning System (GPS) unit to delineate the wetted network over a range of moderate flow conditions that can be expected most of the time (e.g. exceedance probabilities of 25 to 75%). We found that drainage density can span an order of magnitude over nearly two orders of magnitude of discharge. Stream contraction proceeds by increasing disconnection and disintegration into pools but also migration down-slope or the disappearance of flow origins. Physiographic provinces differ by the average upslope accumulated area of origins for a given runoff as well as by flow origin density. Geospatial terrain analysis will be used in future work to create models that explain wetted stream extent as a function of discharge, topography, geology, and other drainage basin attributes.

7.

Pond aquaculture spatial distribution, production and productivity determinants in Ghana

Iris E. M. Fynn and Emmanuel A. Frimpong

The global supply of wild-caught fish has long peaked and efforts to keep up with a growing demand for food fish depend largely on increasing aquaculture production.

Sub-Sahara African countries such as Ghana depend heavily on fish for affordable and valuable protein, but aquaculture production and productivity are markedly low and aquaculture is widely considered unprofitable across the region as a means of livelihood. To optimize production and profitability of small-scale pond aquaculture, it is important that fish farming enterprises are located in areas where the biophysical and socioeconomic conditions are coincidentally conducive and the limited infrastructure are accessible to as many farms as possible. In this study, we mapped the current location of aquaculture infrastructure and services in Ghana and provided alternative locations of future farms and associated infrastructure and services that will ensure optimal production and marketing activities of the aquaculture sector in the country. The specific objectives of this study were to: 1) determine the relative suitability of areas in Ghana for aquaculture, 2) estimate the number of ponds in the country by region, and 3) identify the area of ponds in the country by region. We used satellite imagery and GIS data in combination with field observations, to develop maps of site suitability. The results showed a significant underestimation of the number of fish ponds in the country by previous accounts. Strategic establishment of hatcheries in specified locations in the country is one measure that could accelerate aquaculture development and fish production in Ghana.

8.

Spatial Distribution of Natural Disaster Mortality in Nepal

Sanam Aksha, Luke Juran, and Lynn Resler

The impacts of natural hazards are typically measured in loss of human lives and economic damages (Borden and Cutter 2008), and recent studies demonstrate that deaths due to natural hazards have increased (CRED 2015, Huggel et al. 2015). Understanding human losses to natural hazards is a crucial component for implementing effective disaster risk reduction programs and policies. This poster examines spatial patterns of natural disaster mortality from 1971-2011 at the village level of Nepal using the DesInventar database. The data establish that close to three-quarters of natural hazard deaths are attributed to either landslide (43.5%) or floods (32.4%). Hazard mortality is mostly clustered in the hills and mountains of central and western region. Also, crude death rate to natural disasters is lower in Terai region where 50.27% of the country population distributed in 17 % of total land. In general, the lower elevation southern plains are impacted by floods, middle mountain regions are affected by landslides, and higher Himalayan regions are affected by snow avalanches. As there is no longitudinally consistent source of hazard mortality data for Nepal, a publicly available database such as DesInventar could be of great help for understanding patterns of mortality and ultimately to inform policy makers, disaster managers, and entities that plan and respond to natural disasters.

9.

Global Identification of High Energy Streams with Google Earth Engine

Eric Chance

A viable method to identify high energy stream segments on a global scale using the Google Earth Engine API was developed. This analysis is intended to identify stream segment and significant geographic features that for reasons such as inaccessible terrain or remoteness are largely unexplored in order to identify areas that may be suitable for whitewater recreation, hydropower development or resource conservation. Using 15 arc second resolution digital elevation model and flow accumulation data, high energy river sections (those with large flows and high gradient) were successfully identified. Stream gradient was determined through a neighborhood analysis of 3x3 and 5x5 cell squares, performed through a manual shifts of the DEM dataset. The accuracy of this analysis is limited by several factors, primarily the coarse resolution and errors within the DEM dataset and the difficulty of performing neighborhood based analysis in the Earth Engine environment, addition of these functions to Earth Engine could significantly improve its functionality for terrain based analysis.

10.

A Brief History of Ancient Map-Making:
Early Depictions of Spatial Relationships

Samantha Jo Fried

As remote sensing is a mapping of spatial relationships, and their contents and complexities, it finds its routes in cartographic practices. The history of cartography is vast, culturally-situated, and comprises. Some historians of cartography agree that animal scent-marking of a given environment is the earliest form of cartography. After all, this *is* a mapping of spatial relationships. However, this brief history will briefly explore visual map-making practices in the Paleolithic era, Ancient Egypt, and the Ancient Near East. Very little map-making was centered around land and territory. Most cartography involved the cosmological and mythological mapping, as well as scenes depicting spatial relationships in everyday life. This brief history will conclude with the following thought: cartography is not merely a form of visual representation but, more specifically, it is a spatial language. This observation is a thread that connects ancient cartography to remote sensing.

11.

Automated Creation of Objects for Representing Harvest Boundaries Across Large Areas Using Readily Available Data

Jobriath S. Kauffman

The ability to automatically delineate forest harvest boundaries is useful for natural resources professionals. Two approaches for creating objects representing boundaries of timber harvests will be compared and contrasted. Disturbance detection algorithms

based on Landsat Time Series Stacks, such as Vegetation Change Tracker (VCT), are useful for determining the number of years since the last stand-clearing disturbance as a proxy for age. Clumps of neighboring pixels of the same "age" generally conform well to harvest boundaries. However, "age" cannot be determined beyond the length of the time series of Landsat images that the algorithm is based on. LiDAR height and structure metrics are also useful for creating stand-sized objects using image segmentation methods. These metrics can be calculated for stands of all ages, but there is generally more measurement error with LiDAR metrics than with "age" derived from VCT. Methods for combining these approaches in a complementary fashion will be considered.

12.

Mapping Forest Nitrogen Enrichment with LiDAR Metrics

Katherine Britt, Dr. Brian Strahm, and Dr. Valerie Thomas

As nitrogen deposition increases globally, ecosystem changes will occur. It is important to understand both the growth response and the locations where nitrogen retention occurs. Stable nitrogen isotopes provide insight into this process, and studies have linked foliar N and vegetation structural properties.
Calculating the difference between foliar and soil $\delta^{15}N$ provides the enrichment value, ε, which indicates nitrogen retention. A retentive system can buffer nearby water bodies, capturing nitrogen through flow and protecting water quality. The ability to efficiently predict enrichment values across large areas is possible using remote sensing. Application of LiDAR metrics predicting enrichment values could allow for managers to identify at-risk ecosystem, to mitigate the effects on water quality, and to identify and promote ecosystems that buffer and protect water quality.
LiDAR data collected with NASA's G-LiHT sensor over the Duke Forest in North Carolina was processed using the USFS Fusion program. Metrics were calculated at the tree level and at the canopy level. Foliar and soil samples were collected to determine $\delta^{15}N$ content and to calculate foliar enrichment. Imagery acquisition and foliar sampling occurred within three days during September, 2013. Relationships between LiDAR metrics and foliar enrichment indicate that simpler relationships exist for pine monocultures than for more complex mixed hardwood areas. Relationships were developed separately for pine and hardwood at the tree level and explained 69% and 77% of the variability in enrichment, respectively. Relationships were applied across the entire study site at the canopy level to investigate spatial trends in landscape nitrogen retention.

13.

Geospatial Education at the Blacksburg Children's Museum: Exploring the New River Valley using satellite imagery

Katherine Britt, Dr. James Campbell, Dr. John McGee, Tammy Parece

The Blacksburg Children's Museum requested a set of displays and supplementary curriculum to introduce museum visitors to geospatial data and spatial reasoning skills. The Virginia Cooperative Extension's Geospatial Program, the College of Natural Resources and the Environment, and Virginia View provided funding to produce a large display for the museum. A 15' by 10' banner was developed, printed, and installed. The banner displays Landsat 8 satellite imagery of a large portion of the region, focusing on the New River Valley, and centered on Blacksburg. The display includes false color imagery and a guide to interpreting imagery to help visitors identify land cover types. The interactive map display aligns with the museum's mission of educating by inspiring curiosity, or *"learning through playing."* The banner complements a suite of geospatial display pieces including a carpet of the Chesapeake Bay watershed, a weather station with interactive data maps and displays, and a map viewing light table. Additional educational materials are being produced for educators to use as a supplement to a visit to the museum.

14.

DYNAMIC LANDSCAPES: CHANGE DETECTION OF EPHEMERAL HABITATS

Michael St. Germain.

Bats species have been experiencing population declines throughout the eastern United States. It is important for land managers to know availability of appropriate habitat to aide in the conservation of certain species. In 2015, an active Indiana bat (*Myotis sodalis*) was discovered on Fort A.P. Hill, a U.S. Army installation along the Piedmont/Coastal Plain boundary near Fredericksburg, Virginia. This finding represents the first confirmed Indiana bat maternity colony in Virginia and the entire Coastal Plain physiographic province. The core roosting area is comprised of a dead-standing loblolly pine (*Pinus taeda*) patch adjacent to a large emergent shrub wetland, within a larger matrix of mature, mid-Atlantic hardwood forests. Snags appeared to be pine beetle (*Dendroctonus frontalis*) and/or prescribed fire killed individuals. Using a 1-2-3 band combination with a histogram equalize (ArcGIS 10.3) from 2012, 2014 NAIP imagery, revealed a specific reflectance signature for recently killed trees. Measuring change detection of recent pine tree deaths from 2012-2014 suggest an average tree mortality / potential roost recruitment of 1.2% annually. Modelling mortality areas with various spatial and topographic attributes has yielded several locations of suitable habitat to be investigated in 2016. Once validated, this model may prove to be a very useful tool in identifying these ephemeral habitats for this endangered species across the installation, Commonwealth, and its geographic range.

15.

Remote sensing of crop residue and tillage practices under different crop rotation systems in the US Corn Belt

Michael Graham

Remote sensing techniques can be used to monitor changes in both crop rotation and tillage practices in agricultural systems. Conservation and reduced tillage, which retain more crop residue cover (CRC) on the soil surface than conventional tillage, have major economic and environmental benefits. A number of remote sensing tillage indices, such as Normalized Difference Tillage Index (NDTI), have been successfully employed to assess tillage practices at the field-scale. Crop rotation, wherein different crop species are grown sequentially in the same field over time, has a number of positive effects, including increased crop yield. Field-scale crop rotation patterns are available nationally through products such as USDA NASS Cropland Data Layer (CDL). Until recently, the most common rotation in the US Corn Belt has been corn (*Zea mays* L.) alternated with soybean (*Glycine max* L.). However, changes in US biofuel policies have accelerated an increase in area planted to continuous corn (CC) at the expense of corn-soybean (C-S) rotation. There also appears to be an interaction between crop rotation and tillage type. Many studies report lower corn yields for CC under conservation and reduced tillage compared to corn yields for both CC under conventional tillage and in C-S rotation. Given the trend toward increased CC in the region, such interactions could have major negative environmental consequences. Therefore, the objective of this study is to determine whether tillage practices differ between crop rotation systems using Landsat-based remote sensing indices (NDTI, minNDTI) and USDA NASS CDL for representative counties in the US Corn Belt.

16.

How good is understory presence detection using lidar?: A region-wide study

Ranjith Gopalakrishnan

Airborne lidar system data has been proved to be useful for making spatially explicit maps of forest canopy characteristics such as canopy height and biomass. But there has been relatively far lesser studies looking at the more challenging problem of sensing of the occluded forest understory using lidar. On the other hand, there is an increasingly critical need for spatially explicit understory maps, given their relevance to wildfire management, and for informing biodiversity and conservation decisions. In this context, we explore the possibility of extending the national forest inventory based point data of understory presence using region-wide, survey quality lidar data for the Southeaster United States. For this, we proposed the development of a simple inferential model that helps understand the basic underlying relationship and associations between lidar predictor metrics and forest understory shrub presence over a wide range of forest types and topographic conditions. The model developed had fair predictive performance (accuracy=60%, kappa = 0.18). Hence, we were able to propose a relatively small set (9) of universal predictor variables, selected from a much larger set considered (60). These metrics represented canopy, understory and topographic conditions and one was an indicator variables of sensor characteristics. We also demonstrated that when the understory condition (presence/absence) is more well defined, the model performance is considerably better (accuracy = 71%, kappa = 0.42).

17.

Automated Surface Detection from Photon-Counting LiDAR in Preparation for ICESat-2 Mission

Mahmoud Awadallah, A. Lynn Abbott, Randolph H. Wynne, and Ross F. Nelson

NASA's Ice, Cloud and Land Elevation Satellite-II (ICESat-2) mission is planned to launch in 2017. It is the successor of ICESat, which acquired data near-globally using the GLAS (Geoscience Laser Altimeter System) sensor during the period from 2003 to 2009. One of the objectives of ICESat-2 mission is to collect elevation measurements over vegetation to facilitate canopy height estimation over a two-year period. ICESat-2 will be equipped with the Advanced Topographic Laser Altimeter System (ATLAS). ATLAS is a micropulse photon-counting LiDAR which collects elevation measurements by a multibeam system. It produces a cloud of discrete points which is expected to be contaminated with high level of noise especially in daytime acquisitions. Estimating ground and canopy surfaces from this noisy point cloud is a challenging process. This poster introduces an automatic algorithm to estimate both top of canopy and ground surfaces in three different simulated ICESat-2 data. The proposed approach relies on various image analysis and statistical techniques including noise reduction using a novel hybrid algorithm and surface estimation and refinement using modified active contour models and statistical local regression analysis. A number of experiments had been performed in order to validate the proposed algorithms. The obtained results show that labeling signal/noise photons can be performed with a high level of accuracy (88% - 98%). The experiments show also that ground and canopy surfaces can be estimated with average RMSE 0.2m - 3.2m for all types of simulated ICESat-2 data in different sun angles, echo systems and design cases.

18.

Survey of Aerospace Mission Analysis Tool Applications in Geospatial Analyses

John Guenther

Aerospace systems such as aircraft, satellites, and Unmanned Aerial Systems serve as collection platforms for much of the remote sensing data available to geographers. In this respect, there is a natural connection between aerospace mission analysis and geospatial analysis. The following work seeks to take advantage of the synergies between analysis software tools (see Tools) in order to carry out more robust analysis than might be possible with a single software package.

19.

Jie Ren

This study integrated remote sensing-derived data for analysis using the Soil and Water Assessment Tool (SWAT) within a geographic information system (GIS) modeling environment to assess impacts of changes of cropping systems and planting/harvest

dates within agricultural landscapes of the Central US Corn Belt. Specifically, this analysis examined agricultural impacts upon sediment and nutrient yields in the Embarras, Upper Scioto, and Upper White watersheds of the Midwestern US. SWAT models were calibrated using 2000-2005 data and validated using 2006-2010 data for stream flows. For the three selected watersheds, the SWAT model-predicted stream flows matched well with USGS observation data. The R2 values for the validation period were 0.75, 0.74, and 0.81 and the corresponding NSE values were 0.73, 0.75, and 0.81 for the selected three watersheds, respectively. For the baseline condition, annual sediment yields (tons/ha/year) ranged from 0.89 to 3.98, average annual total nitrogen yields (tons/ha/year) ranged from 8.18 to 13.38 and average annual total phosphorus yields (tons/ha/year) ranged from 1.15 to 1.94. Based on various management scenarios, intensive crop rotation increased sediment and nutrient yields while longer growing seasons for crops decreased sediment and nutrient yields.

20

Global Satellite Navigation System Approach to Total Electron Content Determination [Test of Space@vt-GPS Lab Infrastructure]

Augustine Dormorvi Yellu

The ionosphere is a layer of charged particles located 40-1000 km above the surface of the earth. Solar radiation ionizes hitherto neutral particles in this region of the atmosphere. The level of solar activity regulates the number of charged particles. The ionosphere presents a frequency-dependent refractive index gradient in the path of a radio signal that propagates from a space-borne/earth-based transmitter to an earth-based/space-borne sensor. Global Navigation Satellite Systems such as GPS rely on the transit time of a signal from a space-based satellite to determine the position of a receiver. Ionospheric refraction dithers the signal transit time and causes position errors when a single-frequency receiver is used to reckon position. However the position error caused by the ionosphere can be mitigated if a model of the ionospheric activity is available. A simple model of the ionosphere can be obtained by determining a metric known as the total electron content. In this poster the method of determining the total electric content is outlined, total electric content results computed using measurements from GPS (U.S), GLONASS (Russia), Galileo (Europe) and BeiDou (China) satellite systems presented, and the facilities available at Space@vt-GPS Lab for conducting total electron content research shown. The merits of using total electron content measurements from multiple satellite constellations is also illustrated.

21

Wavelet-based Spatial Temporal Adaptive Data Fusion Model

Sherin Ghannam, A. Lynn Abbott, Mohamed E. Hussein, Mahmoud Awadallah and Randolph H. Wynne

In order to increase the benefit from the huge amount of moderate spatial resolution data offered by the Landsat missions, merging this data with higher temporal resolution sensor data has attracted the remote sensing community. This sort of spatiotemporal fusion enables the tracking of the rapid changes and the ecosystem disturbances. A primary Landsat-MODIS wavelet-based fusion model was proposed in our previous work. In the earlier version of the work, the model was tested over one year interval and the results were promising. In this work, a more generalized and stable version of the algorithm is presented and more experiments are performed to evaluate its performance. The proposed technique is tested on 24 preprocessed Landsat-MODIS image pairs of a heterogeneous study area around Greensboro in the time interval 2000 - 2002. Both prior and posterior Landsat - MODIS pairs besides the MODIS image at the prediction time are used in the prediction procedure. The performance of the proposed technique is compared to the well-established Spatial Temporal Adaptive Reflectance Fusion Model (STARFM). Despite the simplicity of the proposed model, the coefficient of determination (R2) and the squared correlation coefficient (r2) values of the predicted images using the proposed model are better in most of the cases.