

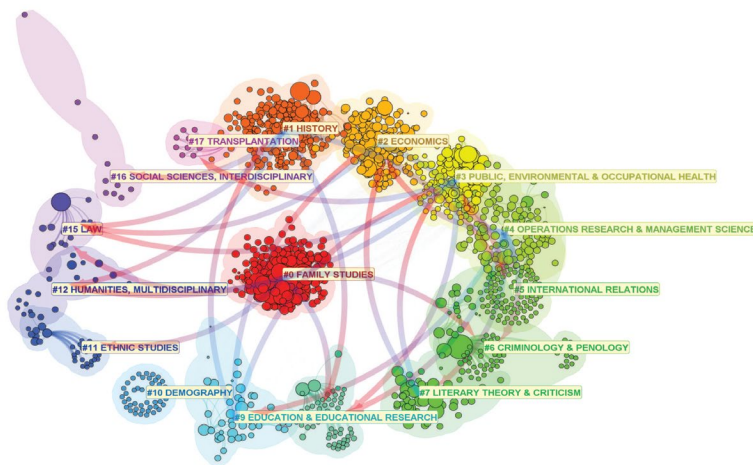


Academic year in review, 2024-2025

Research

The Center for Geospatial Sciences promotes cross-disciplinary work and aims to leverage geocomputational and geoinformatics methodologies to solve problems, enhance decision-making, and improve public policy. We work with various stakeholders and research groups within the UC system, the United States, and internationally, along with numerous government agencies and private companies. The following short report highlights a handful of successes and active collaborations for CGS for the 2024-2025 academic year.

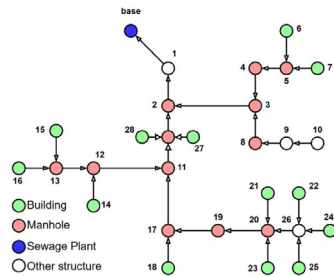
1. NSF D-ISN: TRACK 1: A Holistic Approach to Discovery, Modeling, and Interdiction of Drug and Human Trafficking Networks in the U.S. Southwest (Grubestic)



This NSF project (\$1m) employs a multiscale geocomputational approach that analyzes and develops macro- and micro-level interventions for discovering and interdicting illicit networks. This project enhances national public safety, health, and welfare by improving our understanding of drug and sex trafficking networks, detecting their operational patterns, and developing mechanisms to disrupt their

activities. We include rigorous fieldwork with detectives and survivors and analysis methods from social sciences, operations research, computer science, and information science. The structured data repository resulting from this project will be publicly available to the research community. We actively collaborate with the Las Vegas, San Diego, Phoenix, and Honolulu Police Departments in this project. Our most recent publication, a comprehensive scientometric review of human trafficking, appears in the *Journal of Human Trafficking*.

1a. An Optimization Approach for Biosurveillance in Wastewater Networks (Grubestic and Helderop)



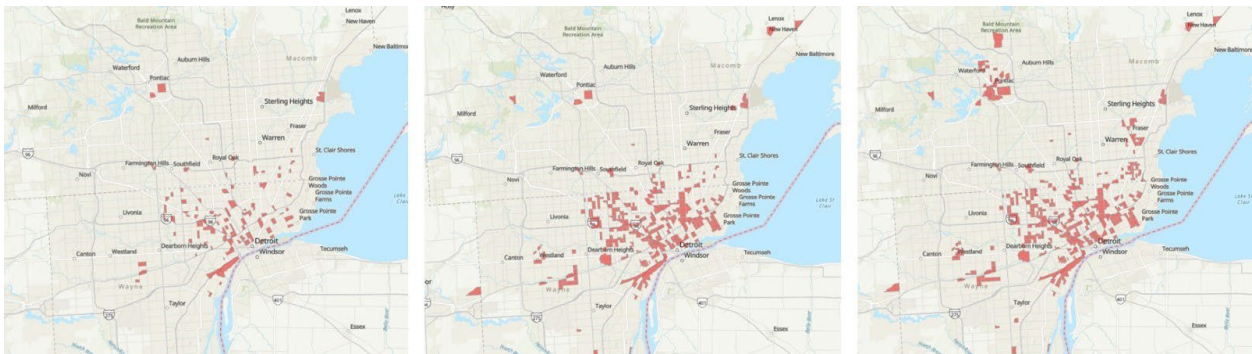
(a) Sample Wastewater Network

Our network analysis approaches developed in the NSF D-ISON project also yielded a spinoff paper (*IISE Transactions*) with collaborators from Boston Fusion, the Charles Draper Stark Laboratory, and others concerning optimal approaches for biosurveillance in wastewater systems. Biosurveillance is the ongoing systematic collection, analysis, and interpretation of biospheric data essential to planning, implementing, and evaluating national security interests. Biosurveillance efforts often

focus on disease activity and threats to human, animal, or plant health to improve situational awareness and early warnings of disease emergence or activity. Wastewater-based epidemiology is an important subdomain of biosurveillance that monitors the consumption of, or exposure to, chemicals and pathogens at the community/population level. However, ecological, environmental, economic, cultural, and political variability yields an asymmetric landscape of threats, subsequent exposure(s), and community burden. This work presents an exact approach based on mixed-integer programming to optimize sensor placement in a wastewater network. The primary goal is to maximize the information captured from the network while narrowing down the potential geographical sources of chemical or biological markers (i.e., signals). We use the wastewater systems of Los Angeles (USA) and Regina (Canada) to demonstrate the scalability of our approach in realistic scenarios and how it can enhance stakeholders' ability to identify emerging threats or assess the effectiveness of strategic interventions post-deployment.

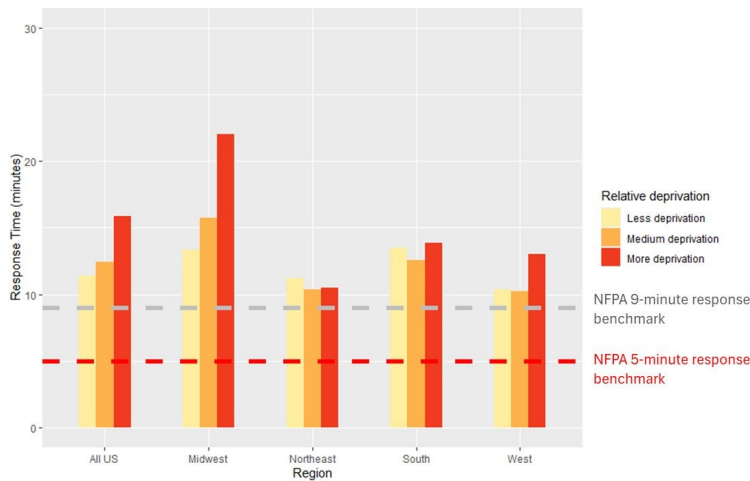
2. Inequities in water and sewerage utility rates (Grubestic and Helderop)

We continue our work on water infrastructure equity in the United States. For this project, we gathered water and sewerage rate data for several cities across the U.S. to study the disparity in utility payments between households of differing demographics and municipalities. We collaborate with colleagues from Michigan State University for this work, have published one manuscript (*GeoJournal*), submitted two others, and are working on two more. We also wrote a piece for *The Conversation* (<https://tinyurl.com/29js98tw>), a news organization that works to bring academic findings to broader audiences.



Block groups in and around Detroit are experiencing unaffordable water and sewer utility bills for average household utilization rates.

3. Measuring the relationship between timely EMS access and neighborhood demographics for critically injured trauma patients (Wei and Helderop)



Mean response time by neighborhood socioeconomic deprivation across the United States.

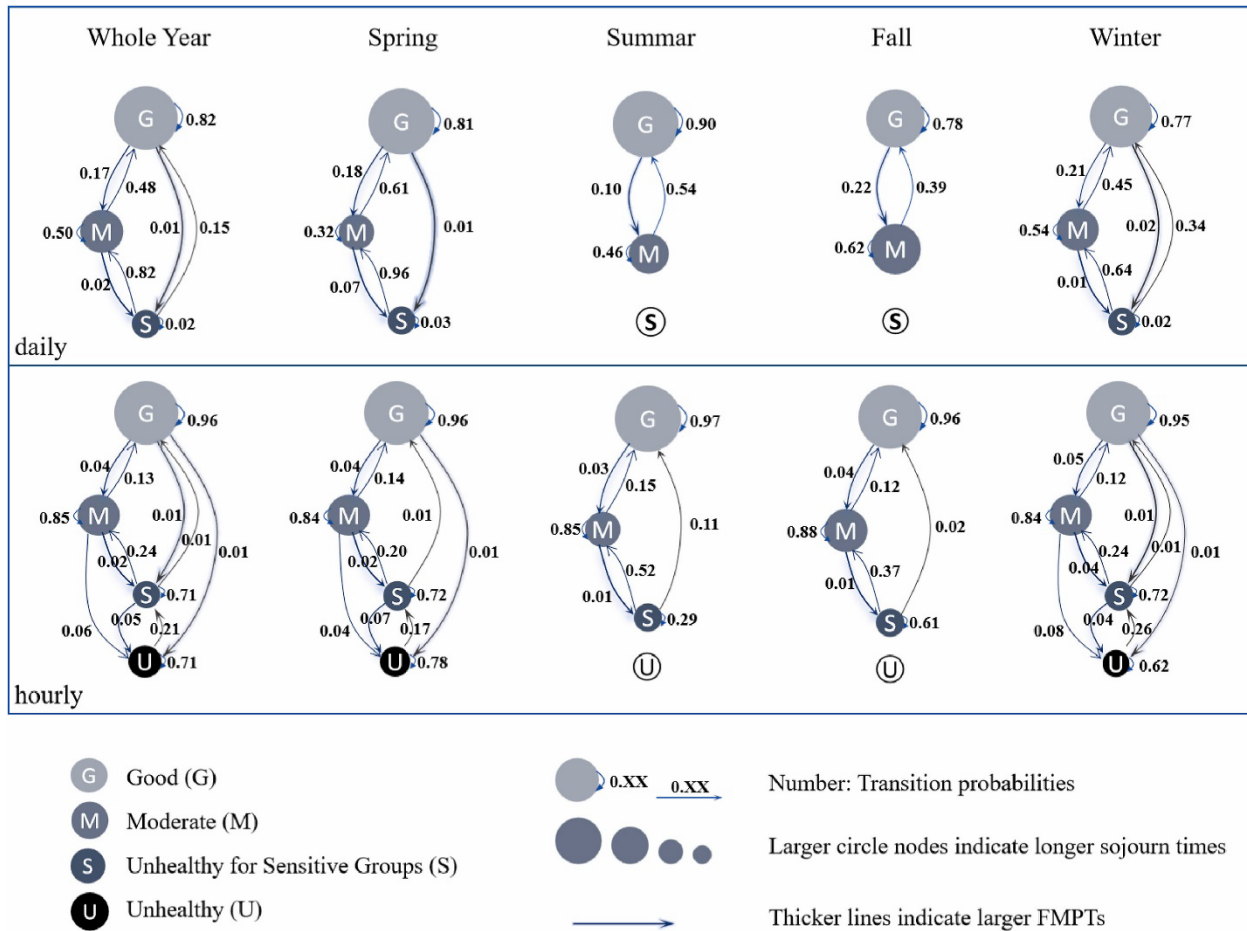
including the response time by EMTs to an injured patient, time on-scene by the EMTs, and the travel time between that patient and a medical facility. With over 200,000,000 patient records in that time, we are drawing detailed conclusions about regional variations in trauma care. Our accepted work will soon appear in several high-profile conference proceedings and journals, including the *Eastern Association for the Surgery of Trauma*, the *New England Journal of Medicine*, and the *American Association for the Surgery of Trauma Annual Meeting*.

Wei and Helderop collaborate with a team of trauma care surgeons from NYU and Rutgers as part of a \$2.4 million NIH grant to explore various facets of emergency medical services (EMS) access and care with neighborhood-level demographic data and patient characteristics. Using five years of National Emergency Medical Service Information System data, our work examines a suite of medically-relevant EMS variables,

4. Exploring spatiotemporal dynamics, seasonality, and time-of-day trends of PM2.5 pollution with a low-cost sensor network: Insights from classic and spatially explicit Markov chains (Grubestic and Kang)

Fine particulate matter (PM2.5) is a major health and environmental concern, with significant spatiotemporal dynamics in urban areas. Low-cost air quality sensor (LCS) networks offer a paradigm-changing opportunity to acquire high spatiotemporal resolution data, revealing the urban pollution landscape with sufficient detail for effective policymaking and health assessment. This collaborative study with UC Berkeley and the University of North Texas appears in *Applied Geography*. It advances geospatial air quality research by using classic and spatial Markov chains to analyze the seasonality and intra-daily variations of PM2.5 using LCS data. Results highlight distinctive PM2.5 seasonality, with the "Good" state predominating in summer and least common in winter. Midday is the peak period for the "Good" state, while mornings and nights have poorer conditions, suggesting a need for stricter pollution control during evening traffic rush hours. Notably, the impact of temporal scale on spatial Markov analysis is substantial, showing a broader range of air pollution states, increased stability, and reduced variation between time intervals compared to daily assessments. Site-level analysis reveals that rural sites are more likely to maintain a "Good" state and less likely to transition out of it. Overall, this study highlights the

effectiveness of high spatiotemporal resolution data and demonstrates the capacity of Markov chains to reveal nuances in phenomena such as air pollution.



State diagrams of classic Markov models for the daily scale (top row) and hourly scale (bottom row). Larger circle nodes indicate longer sojourn times, and thicker lines indicate larger FMPTs. Transition probabilities are labeled. G: Good; M: Moderate; USG: Unhealthy for Sensitive Groups; U: Unhealthy; VU: Very Unhealthy; H: Hazardous.

5. Scale and Correlation in Multiscale Geographically Weighted Regression (MGWR). *Journal of Geographical System (Kang).*

Multiscale Geographically Weighted Regression (MGWR) extends Geographically Weighted Regression (GWR) by allowing process heterogeneity to be modeled at different spatial scales. While MGWR improves parameter estimates compared to GWR, the relationship between spatial scale and correlations within and among covariates - specifically spatial autocorrelation and collinearity - has not been systematically explored. This study investigates these relationships through controlled simulation experiments. Results indicate that spatial autocorrelation and collinearity affect specific model components rather than the entire model. Their impacts are cumulative but remain minimal unless they become very strong. MGWR effectively mitigates local multicollinearity issues by applying varying bandwidths across parameter surfaces. However, high

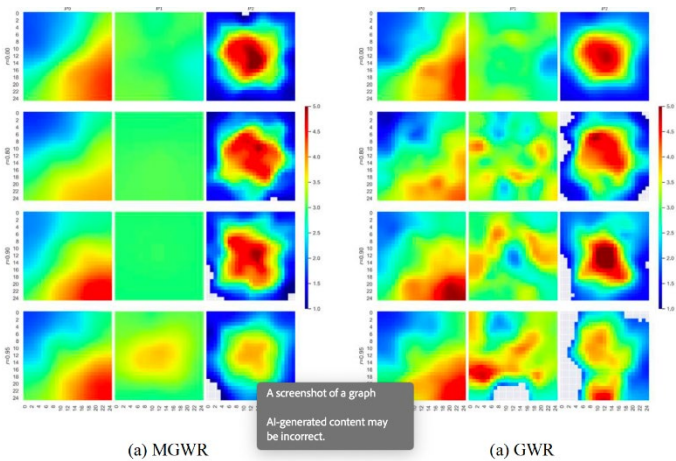
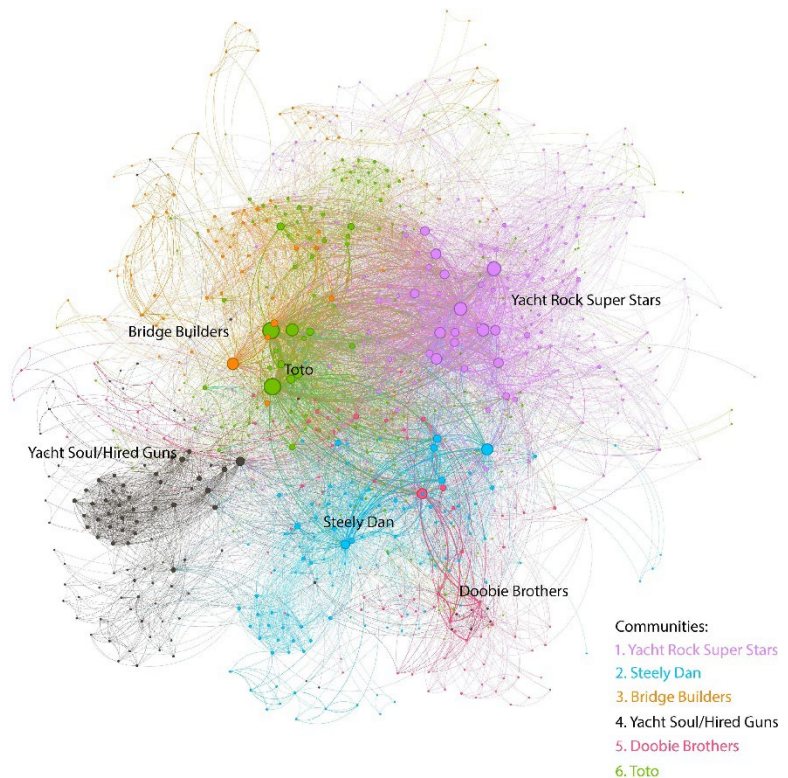


Fig. 5: An example of parameter estimates for scenarios where both covariates are exempt from spatial autocorrelation ($n = 625, \sigma = 1.5$) (statistically insignificant estimates filtered).
 the potential (strong) influence of spatial autocorrelation and collinearity.

spatial autocorrelation and collinearity levels can lead to bandwidth underestimation for global processes, potentially producing false local effects. Additionally, strong collinearity may cause bandwidths to be overestimated for some processes, which helps mitigate collinearity but may obscure local effects. These findings suggest that MGWR offers greater robustness against multicollinearity than GWR; however, one should interpret bandwidth estimates cautiously, acknowledging

6. A Deep Dive into the Collaborative Networks of Yacht Rock (Grubestic and Helderop)

This project, appearing in the journal *Poetics*, explores the collaborative networks of Yacht Rock, a genre of music that emerged in the late 1970s and early 1980s and is currently experiencing a resurgence of popularity in the United States and beyond. In addition to using formal social network analysis to explore the development and transformation of Yacht Rock's collaborative musical network through time, we identify its most influential artists and musicians and highlight the most pivotal songs of the era, adding context with historical and archival approaches. The results indicate that a core group of studio musicians based in Los Angeles played an essential role in helping develop Yacht Rock. This reservoir of musical talent and the supporting "hard" infrastructure (e.g., recording studios, music labels) in Los Angeles helped bring Yacht Rock to the masses. However, much of this movement's success is rooted in the region's "soft" infrastructure (e.g., management, industry connections) and the network effects of bands like Toto and Steely Dan.



7. Additional Funded CGS Research Projects

a) NSF 2024-2026: POSE: Phase II: An Open Source Ecosystem for Spatial Data Science (Kang).

This NSF-funded project (\$1.48 million), supported by the Pathways to Enable Open-Source Ecosystems (POSE) program, aims to advance spatial data science by developing the open-source Python Spatial Analysis Library (PySAL). UCR leads the education and workforce development component, focusing on training the next generation of spatial data scientists. This effort includes conducting an international survey, creating curriculum materials, supporting instructors, and promoting inclusive, participatory learning. UCR's work is central to building a sustainable and accessible ecosystem that empowers users to apply spatial analysis tools to real-world societal challenges.

b) Short-term Environmental Exposures and Emergency Medical Service Activation in the U.S. NIH National Institute of Environmental Health Sciences (Wei).

This NIH-funded (\$1.6 million) project explores the nationwide associations between environmental exposures and emergency medical services (EMS) events. The multidisciplinary team will analyze data on annual 20+ million transports of 911 calls with detailed information on demographics and symptoms, providing statistical power to detect small differences in associated estimates across subpopulations. We will produce crucial evidence for future research to elucidate underlying pathophysiological pathways through which the environment affects health and inform policy. The unique characteristics of EMS data will be integrated with recent advancements in low-cost sensor technologies and newly available smartphone-based mobility data to improve exposure estimates and examine exposure misclassification. Methodologies and frameworks generated in this work will create a key resource for other investigations. We seek to advance paradigms in exposure assessment methods while addressing critical knowledge gaps regarding the potential impacts of environmental exposures on EMS services in the U.S

8. Research Development

a) Further exploration of the relationship between cannabis dispensaries and opiate overdoses

Our work with Dr. Christopher Fichtner, UCR's Chair of Psychiatry and Neuroscience, continues. Previously, we explored the palliative effect of cannabis dispensaries on opiate overdose deaths in Riverside and San Bernardino counties. We have now expanded this analysis to California, with a specific eye towards determining the impact of the COVID lockdown on this relationship.

b) NSF grant submission to explore rural broadband cooperatives

Helderop submitted a Strengthening American Infrastructure (SAI) grant, entitled "Human-Centered, Replicable Rural Model for Strengthening America's Broadband Infrastructure," with Dr. Keith Taylor, from UC Davis's Department of Human Ecology. This grant aims to identify factors that make rural broadband cooperatives successful in producing a generalizable framework to help rural municipalities set up their own cooperatives to achieve similar goals.

c) Abundance Accelerator Research Consortium

Helderop's work as a member of the Abundance Accelerator Research Consortium (\$40k) continues, with his hosting a panel discussion on broadband abundance policy for California in September 2024. He has also written an op-ed on the same topic and is currently writing a position paper to cap off his involvement with the project.

Events and teaching

Over the past year, the core CGS team (Grubestic, Wei, Kang, and Helderop) led a schoolwide (SPP) effort to develop a new major/minor for SPP in Geospatial Analysis and Public Policy. This proposal and developing related course syllabi required substantial time and pedagogical effort. We hope to launch the minor in 2025. Portions of this effort were supported with an award from UOnline (\$140,000).

CGS faculty teach a range of geospatial and geoinformatics classes, along with some additional SPP courses, and this year was no exception:

- PBPL 010 – Introduction to Geographic Information Systems
- PBPL 177 – Housing Policy
- PBPL 236 – U.S. Census Data and Policy Studies
- PBPL 255 – Mapping for the Common Good
- PBPL 273 – GIS and Public Policy

CGS engages in several outreach activities each year as well, including the following:

- An annual presentation of ongoing CGS research at UCR's Geospatial Meetup.
- Drone demonstration for graduate students in Mapping for the Common Good (PBPL 255).
- Joint activities and scholarship with the student GIS club.
- Research presentations at the North American Regional Science Association Annual Meeting, the Association of American Geographers Annual Meeting, and the Institute for Operations Research and the Management Sciences Annual Meeting.

Forecasted activities for the 2024-2025 academic year

Many CGS research projects will likely continue through Autumn 2025 and Spring 2026. In addition, we are exploring pathways to find additional research support that does not rely upon federal monies.