GOLDWATER SCHOLARSHIP

CHEMICAL ENGINEERING GOLDWATER RECIPIENT:

2021-2022 APPLICATION

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PROFILE INFORMATION

PERSONAL DETAILS

First Name	Adele
Last Name	O'Connor

CAREER/PROFESSIONAL ASPIRATIONS

What is the highest degree you plan to obtain?	Ph.D.
In 1-2 sentences, describe your career goals and professional aspirations. It will be used in publications if you are selected as a scholar	I aspire to pursue a Ph.D. in biochemical engineering to become a research professor who advances medicine by extending the use of stem cells in environmental toxicology

What are your career goals and aspirtations? Indicate which area(s) of mathematics, science, or engineering, you are considering pursuing and specify how your current academic program and your overall educational plans will assist you in achieving your career goals and professional aspirations

The Refugees Exploring the Foundations of Undergraduate Education in Science (REFUGES) Program for underrepresented students held a weather balloon launch that had unforeseen impacts on my development as a scientist and on my devotion to environmental research. Working by the Great Salt Lake collecting data to depict the atmosphere's temperature trends instilled a curiosity for the process of scientific discovery within me that I've had ever since.

The REFUGES program fostered my appreciation for the learning environment research provides, which motivated me to participate in the Science Research Initiative program, the University of Utah's Summer Program for Undergraduate Research, and the UCLA Bruins-in-Genomics REU. I've since presented the results of these projects at several national and international conferences where I've collaborated with my community, legislative representatives, and research leadership on my work to innovate environmental-related medical solutions. Engaging in cutting-edge scientific research where I've implemented contemporary procedures, employed creative problem solving, and discussed avenues for project expansion with conference attendees has cemented my desire to become a biochemical engineering researcher.

Through my research experiences, I learned skills that helped me excel academically, which I shared through my teaching assistantship. As a teaching assistant, along with leading group discussions where I've taught students how to advance their programming skills and laboratory data collection and processing techniques, I've instructed my class sections to help students overcome intellectual insecurity and become enthralled in engineering, which has been instrumental in my motivation to aim for a professorship.

As a chemical engineering undergraduate, the multidisciplinary courses I've taken have supplemented my teaching and research goals by providing me with a flexible engineering education with medical and environmental emphases. My classes have had a mutualistic relationship with my research projects and will have immense applications in the research fields I will pursue through my Ph.D. I hope to center my electives around biochemistry and bioengineering, which will prepare me for my career in medical biochemical research.

Through my time as a research and teaching assistant, I've grown to be intrigued by the intersection between chemical engineering, the environment, and the medical field. My studying the confluence of these fields, I've recognized potential for the employment of stem cells in understanding environmental impacts on human health. I strive to participate in more engrossing, impactful roles through my Ph.D. in biochemical engineering, where I aspire to become a professor and principal investigator that advances stem cell-based toxicology studies on air pollution and water contamination.

Describe an activity or experience that has been important in helping shape or reinforce your desire to pursue a research career in STEM.

The summer preceding my first year of university, I was accepted to the Refugees Exploring the Foundations of Undergraduate Education in Science (REFUGES) summer bridge program, where I had the opportunity to engage with other first-generation, traditionally underrepresented University of Utah STEM students and faculty. Along with weekend trips to explore geologic formations and the opportunity to launch an atmospheric weather balloon, we participated in University of Utah courses that emphasized minority health disparities and their corresponding outcomes. We specifically targeted the prevalence of diabetes in Native American communities, Mexican immigrants' inaccessibility to health care, and African American babies' low birth weights. Through the discussion of possible solutions to these health detriments and recognition for their systemic roots, the value of representation in STEM fields became evident to me. As a first-generation Latina, the REFUGES program empowered me through a diverse cohort and valuable mentorship from ethnic minority instructors. I strive to advocate for the representation of students like my REFUGES peers and me because I recognize that we offer invaluable perspectives when addressing inequities in our systems and are necessary for the advancement of the STEM fields.

In what way did COVID-19 or other hardships over the past couple years affect your research career plans and did those events alter your ability to pursue those plans? If you have had to make changes, in what way(s) did you adapt to the situation? If COVID-19 did not influence your plans, simply state there was no impact.

Prior to the pandemic, I had been immersed in research through the Science Research Initiative program at the University of Utah. I conducted organic electrocatalytic synthesis experiments and was set to begin an independent project the following summer until university COVID-19 guidelines halted wet lab work for undergraduate students. I instead accepted a position through the University of Utah's Summer Program for Undergraduate Research (SPUR) in the Department of Biomedical Informatics. Because my mentors gave me significant autonomy towards the project's development, the SPUR program allowed me to feel like a real scientist. The ability to extract optimal procedures and datasets from scientific literature served as a continuous incentive for developing this project, often causing me to lose track of time. This project enlightened me on a path towards a career where I could contribute to that body of biomedical scientific literature. Through my presentation at an air quality conference, I spoke with researchers and professors who gave me further insight into the environmental sciences. This experience further augmented my resolve to study environmental impacts on human health and my understanding of the necessity for environmental stewardship. I was accepted for an Undergraduate Research Opportunities Program grant and a National Institute of Health National Library of Medicine Fellowship to continue this biomedical informatics research into my sophomore and junior years.

Optional Question: Goldwater Scholars will be representative of the diverse economic, ethnic and occupational backgrounds of families in the United States. Describe any social and/or economic impacts you have encountered that influenced your education - either positively or negatively - and how you have dealt with them.

As a daughter of Mexican immigrants, I grew up in a trailer park in Huntington, Utah, a rural coal-mining town with a population of 2,150. My parents didn't have the opportunity to complete middle school, so my father was employed as a coal miner while my mother worked in hotel housekeeping. Throughout my childhood and adolescence, I learned how to speak English through assistance from the elementary and middle school ESL programs. I regularly attended speech therapy due to my lisp and accent, which often limited my communication skills. Despite these difficulties, initiated by my 4th-grade science fair investigation into the possibility of growing plants without soil, I found refuge in the field of science. This allowed me to present valuable findings that weren't fully inhibited by my speech impediment, financial standing, or background as a first-generation Latina. I've since had the opportunity to be a judge at science fairs, allowing Hispanic and Latino students the choice to present their findings in Spanish. I participate in the chemical engineering K-12 Outreach club and work with my community to emphasize how fundamental rural and diverse scientists are for the development of the STEM fields. Through my involvement, I will continue to strive to create an inclusive environment for students who may likewise find STEM as a source of refuge and subsequently as a source of fulfillment.

RESEARCH PROJECTS AND SKILLS

RESEARCH PROJECT #1

Investigating Electrocatalytic Organic Sythesis and Cyclic Voltammetry

Dates	01/2020-05/2020
Average Hrs/Wk	10 (academic year)
Name of Project Mentor	Shelley Minteer; Henry White; Christian Malapit
Position and Affliation of Project Mentor	Dale and Susan Poulter Endowed Chair of Biological and Associate Chair of Chemistry; Distinguished Professor of Chemistry and Widstoe Presidential Endowed Chair in Chemistry; NIH Pathway to Independence Investigator at the NSF Center for Organic Electrochemistry University of Utah
Where the research was performed	University of Utah
Do you have paper/publications/presentations related to this project?	No

Description of research, including your involvement in AND contribution to the project

Electrocatalytic carboxylation provides an avenue for synthesizing greener, safer, and more economic pharmaceutical molecules through the use of electrons and carbon dioxide. To investigate this idea, I determined the ferrocene diffusion coefficient in acetonitrile using voltammetry with varying scan rates through analysis using the Randles-Sevcik equation. Additionally, I conducted electrolysis using a cobalt catalyst, ligand, and substrate solution with carbon dioxide and multiple alkyl halides. Through the Science Research Initiative program, I obtained funding that allowed me to gain a strong understanding of cyclic voltammetry and electrocatalytic organic synthesis through computational and bench laboratory work. My contribution to this project provided me with the tools to apply advanced electrochemical methods to formulate ideas, hypotheses, and conclusions to build a strong foundation for future research.

Research Skills: Briefly describe any research skill(s) you developed while working on this project that will be important going forward in your research

I acquired training in electrochemistry laboratory techniques, including electrolysis, cyclic voltammetry, liquid-liquid extraction, rotary evaporation, thin layer chromatography, and nuclear magnetic resonance spectroscopy.

RESEARCH PROJECT #2

Satellite-Derived Air Quality Measurements in Health Applications

Dates	05/2020-ongoing
Average Hrs/Wk	15 (academic year); 20 (summer)
Name of Project Mentor	Julio Facelli; Ramkiran Gouripeddi; Naomi Riches
Position and Affliation of Project Mentor	Interim Chair Department of Biomedical Informatics and Biomedical Informatics Professor; Biomedical Informatics Assistant Professor; Postdoctoral Research Fellow University of Utah
Where the research was performed	University of Utah
Do you have paper/publications/presentations related to this project?	**Author (but not the first Author); Poster (3) Presenter** Riches NO, Gouripeddi R, Payan-Medina A, and Facelli JC. 2021. Characterization of Multi-Pollutant Outdoor Air Composition and Type 2 Diabetes Mellitus: A Machine Learning Investigation. Manuscript submitted for publication. Payan-Medina A, Riches NO, and Gouripeddi R. Using Satellite Data to Quantify the Impacts of NO2 and PM2.5 on Type 2 Diabetes. Poster session presented at: Air Quality: Science for Solutions; 2020 June 17-18; Weber, UT. Payan-Medina A, Riches NO, Gouripeddi R, and Facelli JC. Implementation of Satellite-Derived Air Quality Measurements in Health Applications. Poster session presented at: National Conference on Undergraduate Research; 2021 April 12-14; Virtual. Payan-Medina A, Riches NO, Gouripeddi R, and Facelli JC. Characterizing Satellite-Derived Air Quality Measurements for Health Applications. Poster session presented at: International Society of Exposure Science Symposium; 2021 August 30-September 2; Virtual.

Description of research, including your involvement in AND contribution to the project

Exposure to criteria pollutants has been correlated to increased cardiovascular or respiratory health risks and inflammatory or metabolic insults. Widespread air pollution coverage is not available for proper biomedical analysis. To expand the spatial-temporal availability of air quality data, I created Python codes that download NASA satellite data measurements, reverse geocode the data spatially at the census tract, and organize the data by year. This NASA satellite chemical pollution infrastructure optimizes biomedical informatics research studies by providing datasets for the criteria pollutants that offer daily, widespread, practical chemical pollution measurements. I determined where ground-based monitors and satellite data were optimal through multiple correlation tests, including Pearson, Spearman, and T-Tests. I am currently assembling a web-based application that facilitates satellite data retrieval at the census tract for population exposure studies.

Research Skills: Briefly describe any research skill(s) you developed while working on this project that will be important going forward in your research

I gained a strong background in the development of informatics methods, including correlation analyses, k-means clustering, and statistical analysis. I advanced my programming skillset by formulating data retrieval infrastructures and web development tools formed from NASA and EPA data.

RESEARCH PROJECT #3

NSF REU: Interactive Application for Tracing Atomic Fates in Metabolic Networks

Dates	06/2021-08/2021
Average Hrs/Wk	5 (academic year); 50 (summer)
Name of Project Mentor	Junyoung Park; Richard Law; Edward Ma
Position and Affliation of Project Mentor	Assistant Professor of Chemical and Biomolecular Engineering; Graduate Student; Graduate Student University of California, Los Angeles
Where the research was performed	University of California, Los Angeles
Do you have paper/publications/presentations related to this project?	**Poster Presenter** Payan-Medina A, Watson C, Ma E, Law R, and Park JO. Assembly of an interactive database application for tracing atomic fates in metabolic networks. Poster session presented at: UCLA Bruins-in-Genomics Research Symposium; 2021 August 13; Los Angeles, USA.

Description of research, including your involvement in AND contribution to the project

Metabolite concentrations and fluxes constitute the basis for understanding and engineering metabolism. Mass spectrometry, stable isotopes, and atom mapping are integral tools in quantifying these metabolic features through isotope tracing experimentation. Using Python, SQL database, and SMILES notation for representing molecules and reactions, I built a metabolite visualization engine that generates scalable vector graphics for E. coli central carbon metabolism. I reindexed atom transitions across metabolism by pairwise comparisons of molecule topology, allowing atoms to be accurately traced across the network. Using this visualization engine with consistent atom mapping information, I innovated an integral pathway-level atom mapping technology that visualizes user-selected atoms across metabolic pathways. The upshot is the capability to comprehensively visualize metabolic flux distributions, which accelerates metabolic engineering and therapeutic development endeavors.

Research Skills: Briefly describe any research skill(s) you developed while working on this project that will be important going forward in your research

At UCLA, I gained a background in metabolic flux analysis, atom mapping, isotope tracing, cell culture, and mass spectroscopy. I applied cell biology, biochemistry, molecule topology, and web development fundamentals. I learned how to integrate SQL requests and how to program in JavaScript and HTML.

RESEARCH PROJECT #4

Association Between Ultrafine Particle Exposure and Type Two Diabetes Mellitus

Dates	09/2021- ongoing
Average Hrs/Wk	20 (academic year)
Name of Project Mentor	Julio Facelli; Ramkiran Gouripeddi; Naomi Riches
Position and Affliation of Project Mentor	Interim Chair Department of Biomedical Informatics and Biomedical Informatics Professor; Biomedical Informatics Assistant Professor; Postdoctoral Research Fellow University of Utah
Where the research was performed	University of Utah
Do you have paper/publications/presentations related to this project?	**Poster Presenter** Payan-Medina A, Riches NO, Gouripeddi R, and Facelli JC. Association Between Ultrafine Particle Exposure and Type Two Diabetes Mellitus. Poster session presented at: Utah Conference on Undergraduate Research; 2022 February 25; St. George, UT. Payan-Medina A, Riches NO, Gouripeddi R, and Facelli JC. Association Between Ultrafine Particle Exposure and Type Two Diabetes Mellitus. Poster session presented at: National Conference on Undergraduate Research; 2022 April 4-8; Virtual.

Description of research, including your involvement in AND contribution to the project

Recent studies have demonstrated that ultrafine particles (UFP) can cross the pulmonary alveolar membrane and directly affect systemic inflammation and autonomic dysfunction leading to type two diabetes mellitus (T2DM). To investigate this, I used a land-use regression model to provide long-term, large-scale UFP exposure estimates that capture urban and rural variations as particle number concentration (PNC) measurements for nearly 6 million residential census blocks in the contiguous United States. I matched these yearly PNC geographic coordinates with the county-level T2DM incidence data obtained from the Centers for Disease Control and Prevention for the subsequent year. I created a linear regression model to predict T2DM incidence subject to UFP exposure, with several controls including race, ethnicity, age, income, gender, and education level. These results supplemented our understanding of the validity of the relationship between UFP exposure and T2DM.

Research Skills: Briefly describe any research skill(s) you developed while working on this project that will be important going forward in your research

This project provided me with experience in biostatistical regression methods that utilize clinical data. While implementing my multi-variable linear regression model, I learned how to apply variable selection, select controls, and perform correlation and error analyses.

MENTOR RECOGNITION

LETTER WRITER INFORMATION

OTHER ACTIVITIES/ ACCOMPLISHMENTS

Activity/ Accomplishment	Teaching Assistant
Organization/Scope of Activity	University of Utah/College/University
Role/ Involvement	I help patients find where they need to be in the new hospital layout and help direct visitors to the resources they need. I also help to screen COVID in visitors and staff and ensure safety protocols are met.
Position/Length of Involvement	Teaching Assistant/More than 1 academic year

Activity/ Accomplishment	Chemical Engineering Outreach
Organization/Scope of Activity	University of Utah/Community
Role/ Involvement	I have helped develop and present chemical engineering teaching modules to over 200 K-12 Utah students to introduce them to the chemical engineering major and engage them in STEM subjects, including renewable energy, magnetism, and nanomaterials.
Position/Length of Involvement	Member/Academic Year

Activity/ Accomplishment	Center of Excellence: Exposure Health Informatics
Organization/Scope of Activity	University of Utah/College/University
Role/ Involvement	The CEEHI is a multidisciplinary seminar where health researchers present their recent exposure-health investigations. I participate in discussions and deliver talks and updates on my biomedical informatics research.
Position/Length of Involvement	Member/More than 1 academic year

Activity/ Accomplishment	Grand Challenge Scholars Program
Organization/Scope of Activity	University of Utah/National
Role/ Involvement	The GCSP encourages engineering students to partake in research, service, and interdisciplinary experiences to promote innovation. As a scholar in the health grand challenge, I center my experiences around advancing health informatics and medicine.
Position/Length of Involvement	Grand Challenge Scholar/More than 1 academic year

Activity/ Accomplishment	Associated Students of the University of Utah
Organization/Scope of Activity	University of Utah/College/University
Role/ Involvement	As an ASUU first-year council and sustainability board representative, I organize and participate in volunteering projects and activities to help raise students' environmental awareness. These projects include can and glove recycling initiatives.
Position/Length of Involvement	Representative/More than 1 academic year

RECOGNITIONS

Recognition/Type	NIH NLM Undergraduate Fellowships/National
Year	2021
Description	The NIH National Library of Medicine fellowship is awarded to academically excelling students of underrepresented backgrounds committed to contributing to biomedical research. This award covers my research stipend and tuition.

Recognition/Type	Undergraduate Research Opportunities Program (UROP)/College/University
Year	2020
Description	The Undergraduate Research Opportunities Program (UROP) offers students an opportunity to submit funding proposals to pursue research projects. The UROP program provides a stipend and educational programming when approved.

Recognition/Type	REFUGES Scholarship/College/University
Year	2019
Description	The REFUGES program provides underrepresented STEM students an encouraging peer and mentor group and full summer housing and tuition support. REFUGES scholars take university classes and explore research facilities the summer before freshman year.

Recognition/Type	UCLA Bruins-In-Genomics Research Excellence Award/College/University
Year	2021
Description	I was awarded the Research Excellence designation for the UCLA Bruins-in-Genomics NSF REU. Through a Principal Investigator nomination, this award is for exceptional research performance through the duration of the REU.

Recognition/Type	Vice President's Research Leadership Scholar/ College/University
Year	2021
Description	I was awarded the Research Excellence designation for the UCLA Bruins-in-Genomics NSF REU. Through a Principal Investigator nomination, this award is for exceptional research performance through the duration of the REU.

CURRENT COLLEGE/UNIVERSITY

GPA	4.00
Graduation Year	Spring 2023

COURSEWORK

RESEARCH ESSAY

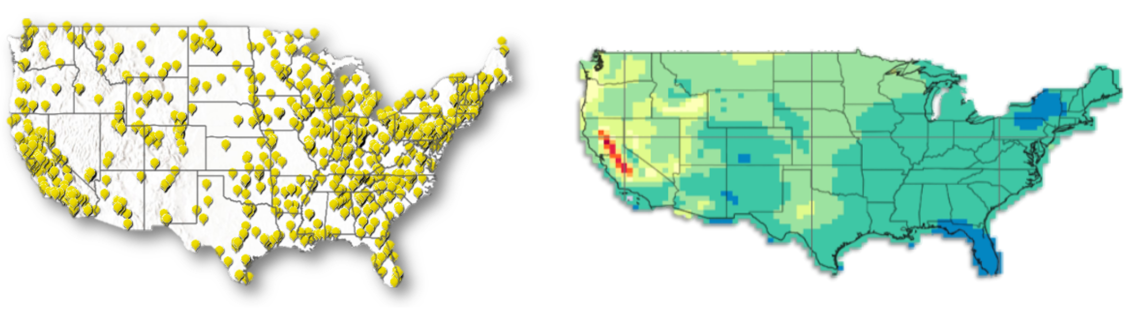
University of Utah

CHARACTERIZATION OF SATELLITE-DERIVED AIR QUALITY MEASUREMENTS IN HEALTH APPLICATIONS

Physiologically detrimental chemicals from motor vehicles, fossil fuels, and industrial emissions can have devastating impacts on global health. Chemical pollution and particulates can be inhaled deep into the lungs and enter circulation within the bloodstream, contributing to tissue damage, increased cardiovascular or respiratory health risks, and inflammatory or metabolic insults [1]. Preliminary studies have shown that criteria pollutants (CO, NO_2, O_3, $PM_{2.5}$, SO_2) stimulate these conditions, potentially promoting an increase in type 2 diabetes mellitus (T2DM) incidence in locations with adverse air quality (AQ) [1,2], inducing lifelong morbidity and encumbering the health care system. Forthcoming economic development and urbanization cause projected increases in air pollution and an increased burden of T2DM incidence [1], demonstrating the need for widespread and accurate pollutant measurements.

Several studies have utilized ground monitored AQ measurements to investigate the correlation between T2DM prevalence and exposure levels, finding statistically significant, positive relationships [1,2]. Unfortunately, not all AQ and T2DM relationship factors are reported consistently: such studies still hold considerable ambiguity concerning the validity of the ground-monitor obtained AQ measurements. A critical issue not successfully addressed is the reliability of a ground-based AQ monitor on those living outside its range. Ground-based monitors are generally located in population-dense areas, leaving 79 million Americans in unmonitored or monitor sparse locations, receiving inaccurate AQ data (Figure 1a) [3].

In contrast, satellite data from the National Aeronautics and Space Administration (NASA) gives access to spatiotemporal air pollution data through global exposure coverage of criteria pollutant concentrations through geographic coordinate specific values (Figure 1b).



(a) *(b)*

Figure 1. *(a) Active Environmental Protection Agency AQ monitors [4], (b) NASA Modern-Era Retrospective analysis for Research and Applications, Version 2 AQ coverage [5].*

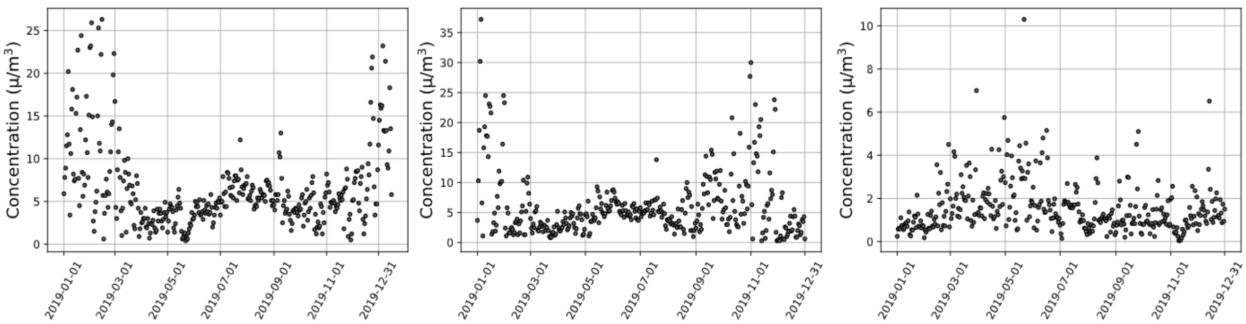
University of Utah

To support epidemiological studies and elucidate health risks correlated to adverse AQ, combining ground monitor data with satellite data has been found to exploit the benefits of both sources. The central objective of my research is to use statistical and correlation analyses to provide a quantitative evaluation of the precision of chemical pollutant data from satellites to optimally combine satellite AQ data with ground-monitor data in biomedical population exposure studies.

To facilitate this goal, I developed a data retrieval infrastructure that created practical, spatially, and temporally widespread chemical pollutant files for the criteria pollutants separated by year. I designed the infrastructure through NASA's Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2) and Ozone Monitoring Instrument (OMI) pollutant concentration measurements, available through geographic-coordinate gridded daily files. After I retrieved these daily files for each of the criteria pollutants, I filtered them for missing days and quality flags that may arise in heavy cloud or snow conditions. I efficiently matched the gridded data to the zip code and census tract level using reverse geocoding with parallelized K-D tree implementation. This NASA satellite data retrieval infrastructure transformed 30 thousand daily chemical pollution files into a data resource with 15 years of criteria pollutant concentration data, organized by year and location with indicators on data missingness and quality.

My research team and I recognized that the validity of satellite data could be emphasized with comparison to ground-based monitors from the Environmental Protection Agency (EPA). To validate the satellite AQ measurements, I performed in-depth statistical and correlation analyses between the EPA and NASA AQ datasets. The procedure to organize and provide EPA data missingness and quality indicators was reminiscent of the NASA satellite data retrieval infrastructure. I then matched each satellite geographic coordinate pair to the closest EPA monitor. I analyzed the measurements with Z-test, Bland-Altman test, T-test, and regression analyses to provide a correlation quantification between the two datasets at any respective location.

With the results of this analysis, satellite data could be used to track pollutant profiles, provide support for AQ forecasting, and provide input to AQ models and data for model evaluation. For example, the closest EPA air quality monitor to Carbon County, Utah, is 145 kilometers away, located in Utah County. As demonstrated in Figure 2, although the Utah County satellite and Utah County EPA monitor measurements model one another, there are significant differences between the EPA and satellite Utah County measurements and the satellite Carbon County measurements. This variation between satellite instrument AQ measurements and EPA monitor measurements quantified through the correlation quantification exemplifies a county where satellite AQ data could provide more precise criteria pollutant concentrations. This illustrates how satellite data have considerable applications in locations lacking AQ monitors or complement data from sites with existing monitors.



(a) (b) (c)

Figure 2. *(a) Utah County EPA, (b) Utah County MERRA-2 Satellite, (c) Carbon County MERRA-2 Satellite 2019 $PM_{2.5}$ Data Trends*

Through the elaborate network of ground monitors and satellite instruments, we attain a more thorough representation of air pollution exposure to a broader swath of the US population and the subsequent evaluation of atmospheric pollution's impacts on diseases stimulated by adverse AQ. As such, my research team and I have found a positive correlation between increasing satellite and ground monitor concentrations of $PM_{2.5}$, PM_{10}, and NO_2 and T2DM incidence using k-means clustering.

I am currently working on accumulating this analysis into a web-based framework. This satellite data retrieval tool features criteria pollutant, date, and geographical region selection, and a correlation statistic between the satellite data selected and the closest EPA monitor's data. The tool retrieves the specified NASA and the corresponding EPA monitor datasets available for download, as well as a data missingness and quality report for both datasets. To further my research, I plan to include meteorological data in the data quality analysis to address unflagged satellite data limitations. Our study will provide insight towards future satellite-health applications, emphasizing satellite data with ground monitors to advance knowledge on chemical pollutants’ contribution to cardiometabolic disease morbidity. Correspondingly, suitable public health legislative policy regarding AQ could be created abreast of reliable, widespread pollutant exposure levels.

REFERENCES

[1] Liu C, Wang B, Liu S, Sheng L, Zhang K, Luo B, and Yang A. 2021. Type 2 diabetes attributable to PM2.5: A global burden study from 1990 to 2019. Environmental International, (156):1-10.
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