Personal, Background, and Future Goals Statement

"What was your favorite memory of first grade?" was the question posed in my first grade yearbook. Seven-year-old me responded with *"learning about the weather and measuring weights in math."* My immediate fascination in those simple lessons foreshadowed a lifelong passion to investigate the world through mathematics and science. This enthusiasm ultimately guided my decision to major in Applied Mathematics (with a specialization in computing) and minor in Atmospheric & Oceanic Science at the University of California, Los Angeles (UCLA).

Alongside rigorous junior-level coursework, I took the initiative to become **a mentor in the Applied Mathematics Mentorship Program (AMMP) funded by the Bill & Melinda Gates Foundation** to inspire young students in mathematics, just as I was inspired during my own K-12 education. Through this program, I critically reviewed methods of teaching curriculum with the goal of increasing Black and Latino/a motivation in STEM. Each week for four months, I enthusiastically engaged nearly fifty seventh-grade students attending an underprivileged school in challenging research investigations of urban heat islands via weekly activities developed by the UCLA Curtis Center for Mathematics & Teaching. In graduate school, I am committed to continuing my involvement in programs like this one, which empower the next generation of STEM leaders and foster a diverse community of scientists.

I am applying to graduate programs in Computational/Applied Mathematics with the goal of becoming a research professor. My interests lie in computational techniques, such as machine learning (ML) and topological data analysis (TDA), to address pressing social and environmental concerns. I aspire to make significant contributions to academia and society at large, while supporting my students and mentees.

Background: I have **undertaken three notable research projects** during my undergraduate career which have showcased my determination and capabilities to implement complex mathematical solutions, work collaboratively in a research setting, and deliver novel results that benefit a broader cause.

During my junior year, I sought a research opportunity that would unite the subjects I explored disjointly in my coursework, mathematics and climate science. I was drawn to the interdisciplinary projects listed as part of the summer 2023 **NSF-funded** "Directed Research for Undergraduates in Mathematics and Statistics" **REU program at North Carolina State University (NCSU)**. I was accepted to the program which gave me the opportunity to build a predictive model of California wildland fire burn severity, measured by the normalized burn ration (NBR), based on pre-fire remotely sensed data from NASA. Under the guidance of Dr. Brian Reich (NCSU), Dr. Pascolini-Campbell (NASA), and Dr. Margaret C. Johnson (NASA), my team sought to show that using a Super Learner algorithm, one that strategically weighs the results of many diverse ML algorithms to produce a single prediction, would outperform any single base learner. I **helped two team members learn Python** and was directly involved in the implementation of eleven diverse ML algorithms. We used hydrological, ecological, and topographical variables collected from satellites as NBR predictors. Due to the large number of pixels, we opted to use Vecchia approximation to account for spatial autocorrelation. **My team published this research** in the *Journal of Environmental and Ecological Statistics* [1].

My senior year, I was **recognized as the sole mathematics recipient of UCLA's Queens Road Foundation Undergraduate Research Fellowship** which provided networking opportunities and scholarship. With this fellowship, I collaborated with Dr. Sarah Tymochko, an expert in TDA, to address questions about resource coverage. I was interested in exploring innovative techniques to identify neighborhoods at risk of heat-related mortality, a critical investigation in light of the increase in frequency of extreme heat events in the United States. We wanted our investigation to inform cities of the ideal placement of additional cooling centers to minimize loss of life. We used the persistent homology of a filtered witness complex to identify census blocks underserved by the current distribution of cooling centers. We analyzed the death times of the 0-dimensional and 1-dimensional features to build a map highlighting the top five most vulnerable locations within four cities. In addition, I created *heat vulnerability index* (HVI) maps that consider demographic variables, such as the number of elderly residents and the percentage of tree canopy in specific areas of the city. By overlaying our TDA findings onto the HVI score maps, we provided a more holistic understanding of coverage and vulnerability for four regions of the US. This **research is in submission to the *SIAM Journal for Applied Mathematics* and is currently available on arXiv** [2]**.**

In the summer of 2024, I was **selected to collaborate with UCLA's Joint Institute for Regional Earth Systems Science and Engineering and NASA's Jet Propulsion Lab (JPL)** on a project that would contribute meaningfully to the study of Earth's climate. Many traditional algorithms assume atmospheric clouds are homogeneous within a remotely sensed footprint to reduce complexity, but this can lead to a loss in the accuracy of climate models. Under the mentorship of Dr. Fishbein (JPL), I aimed to show that accounting for sub-pixel heterogeneity in cloud data would increase the correlation length, a measure of variability within a footprint. I independently developed a Python script that utilized an automated version of the Elbow Method and K-Means to classify heterogenous cloud types based on four variables (cloud top height, cloud effective radius, optical thickness, and cloud phase) derived from the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument. To expedite the computation of correlation length, I learned to compute 2D autocorrelation in the frequency domain. The results indicated that correlation length increased within each cluster compared to the unclustered footprint, provided there was a sufficient amount of valid data. Dr. Fishbein **used my summer research to develop a compelling funding proposal** to enable JPL scientists to explore the effects of accounting for sub-pixel heterogeneity further.

<u>Intellectual Merit:</u> During my undergraduate career, I **co-authored two papers** and have taken on challenging coursework that included the most advanced C++ course offered at the undergraduate level and two graduate level courses this quarter. In the last four years, I have developed the specialized knowledge, problem-solving skills, and determination needed to be successful in graduate school. Beyond my academics, my undergraduate research experience has underscored my commitment to furthering the field and my ability to apply what I have learned in the classroom to real-world problems. Furthermore, during spring 2024, **I was honored to receive the Dr. Paul H. Daus Award, given to just four top-ranked mathematics majors** in their final year of study at UCLA. This recognition highlights my status as a standout student poised to further my research abilities.

Broader Impacts: Besides being a role model and mentor in AMMP, I have also supported a diverse range of students through other initiatives with the goal of increasing participation in STEM. For instance, I dedicated a quarter to helping fourth graders grasp the concept of fraction multiplication and division through CalTeach. In addition, UCLA's Center for Accessible Education commented that I "exceeded expectations" as a peer notetaker for a student with a disability in a physics class. Moreover, through the Queen's Road Fellowship, I contributed to discussions of gender diversity in the physical sciences and mentored an underrepresented student in spring 2024. Finally, this quarter I am providing assistance in the discussion sections of pre-calculus courses through UCLA's Learning Assistant program which emphasizes equitable teaching.

I have become a figurehead in those programs because I am no stranger to the feeling of walking into an academic setting and feeling inferior or out of place. As I have worked in male-dominated study groups, I have felt the weight of stereotype threat firsthand, making me less comfortable to express when I was confused. I have a deep understanding of the importance of diversifying STEM to reduce feelings of anxiety and increase sense of belonging. I found my own community in the UCLA Women in Mathematics group which provides me with a space to talk freely about mathematics with women I look up to. I hope to find and foster similar communities in my future graduate school endeavors.

One idea to foster a collaborative community in graduate school is to establish "paper clubs" for physical science students. Similar to book clubs, these groups would meet regularly to discuss a common academic paper. This approach can help alleviate feelings of inferiority when attempting to read high-level papers on one's own. In addition, this type of collaboration and open dialogue would help build a sense of belonging. Moreover, to encourage more participation in STEM, I will encourage students of all ages and backgrounds to participate in summer programs and conferences, something I greatly benefitted from. As a graduate student and professor, I will share such opportunities with my classmates and students through bulletin announcements, advocate for my university to host similar programs, and maintain a lifelong membership in the Association for Women in Mathematics as a national effort to unite and encourage women in STEM.

Future Goals: I plan to pursue a Ph.D. in Computational/Applied Mathematics and become a research professor. Furthering my education will deepen my knowledge base to be better equipped to advance the field and create opportunities to collaborate with a diverse set of people. I am confident in my ability to be a successful graduate student and utilize my knowledge to better society. Additionally, I am passionate about continuing to mentor and teach aspiring mathematicians and scientists to broaden participation in STEM. Being awarded the NSF-GRFP would greatly enhance my capacity to achieve these goals.

References:

[1] Simafranca, N., Willoughby, B., **O'Neil, E.** et al. Modeling wildland fire burn severity in California using a spatial Super Learner approach. *Environ Ecol Stat* 31, 387–408 (2024). https://doi.org/10.1007/s10651-024-00601-1

[2] **O'Neil, E.**, & Tymochko, S. (2024). Evaluating cooling center coverage using persistent homology of a filtered witness complex. arXiv.org. https://arxiv.org/abs/2410.09067