UMBC

NSF REU EXPLORE

EXPeriments in Earth and Atmospheric Science: **L**earning **O**pportunities and **R**esearch **E**xperience

Summary Report

June 1 – August 7, 2026

University of Maryland, Baltimore County

1000 Hilltop Circle, Baltimore, MD – 21250

This program is sponsored by the National Science Foundation

2026 NSF REU EXPLORE

Dear NSF REU EXPLORE students,

Thank you for choosing to spend your summer with us at UMBC. It has been a privilege to watch you grow as researchers, problem solvers, and members of a scientific community.

The NSF REU EXPLORE program was created to prepare and inspire the next generation of scientists. Through your research at UMBC, we hope that you experienced how science is built through curiosity, collaboration, creativity, and persistence. Whether you were collecting data, writing code, analyzing results, or presenting your work, we expect that every challenge was an opportunity to learn and grow.

I would also like to thank the faculty mentors, graduate students, staff, and collaborators who shared their time, knowledge, and encouragement. Science is a team effort, and this program would not have been possible without their commitment to mentoring the next generation of researchers.

I hope this summer has given you more than research experience. I hope you have built lasting friendships, gained confidence in your abilities, and discovered new possibilities for your future. Whether you continue in graduate school, industry, government, or another path, I hope you carry with you the excitement of discovery and the confidence that you can make meaningful contributions to science and society.

Sincerely,

Adriana Rocha Lima
University of Maryland, Baltimore County (UMBC)
Physics Building
1000 Hilltop Circle, Baltimore, MD, 21250

The NSF REU EXPLORE 2026 program was made possible thanks to the coordinated work of all contributors involved before, during, and after the program.

Responsible Team

Task	Contributors
Principal Investigator	Adriana Rocha Lima
Co-Investigator	Ivona Cetinić
Senior Advisor	Belay Demoz

Evaluation

Task	Contributors
External Evaluator	Kavita Mittapalli

Organization

Task	Contributors
Website	Adriana Rocha Lima and Ivona Cetinić
Program	Adriana Rocha Lima and Ivona Cetinić
Summary Report	Adriana Rocha Lima
EXPLORE Logo	Emily Faber
Check-in and Arrival Day Assistance	Adriana Rocha Lima and Emily Faber
NASA Goddard Space Flight Center Visit	Ivona Cetinić
Goddard on the Green Event	Valerie Casasanto

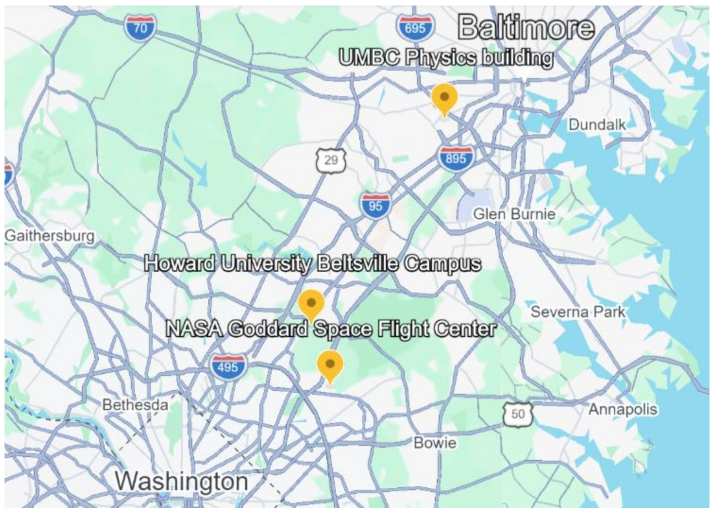
Howard University Beltsville Campus Visit	Nakul Karle and Belay Demoz
Budget Management	Adriana Rocha Lima and Margo Young
Catering	Camilla Hyman and Adriana Rocha Lima
Invited Speakers	Matthew Pelton, Vanderlei Martins, Sampa Das, Ian Carroll, Emily Faber, Maurice Roots, and Kylie Hoffman
Python Bootcamp	Joshua Richards and Maurice Roots
SEM Training	Adriana Rocha Lima and Tagide deCarvalho
Button Making Machine	Daniel Gonzales
UMBC Mugs Gifts	Shakura Newman and Department of Physics
REU Headquarters	Department of Physics Space Committee, Colleen Russell and Erik Crowe
Rides and Support	Marco Carmignotto

We warmly thank all the mentors for their essential contribution and for guiding the NSF REU EXPLORE students in the development of high-quality research.

Acknowledgment to the Mentors

Names
Henrique Barbosa
Ivona Cetinić
Christopher Hennigan
Jasper Lewis
Brent McBride
Anin Puthukkudy
Adriana Rocha Lima
Andrew Sayer
Ali Tokay
Xiaoguang (Richard) Xu
Pengwang Zhai
Zhibo Zhang

Important Locations



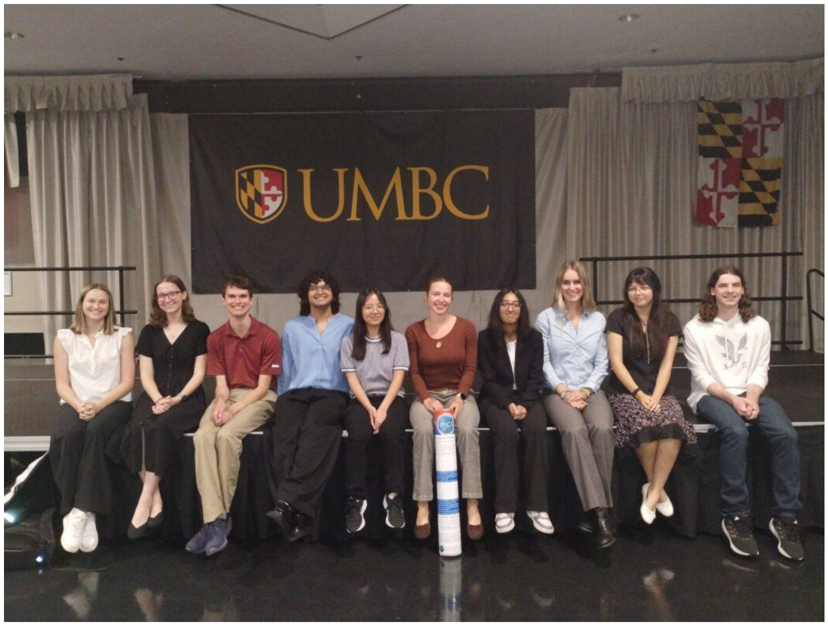
Name	Location
Department of Physics – UMBC	1000 Hilltop Cir, Baltimore, MD, 21250
Howard University Beltsville Campus	7501 Muirkirk Rd, Beltsville, MD, 20705
NASA Goddard Space Flight Center	8800 Greenbelt Rd, Greenbelt, MD, 20771

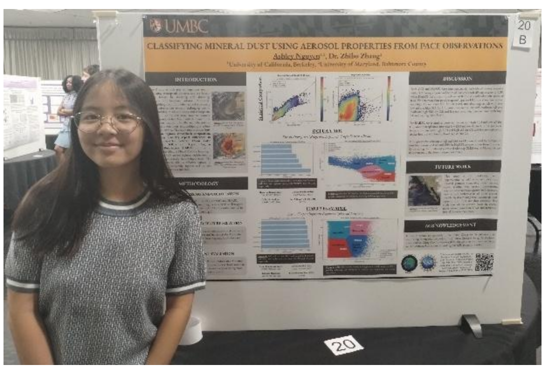
Inaugural Day

NASA Goddard Space Flight Center Visit

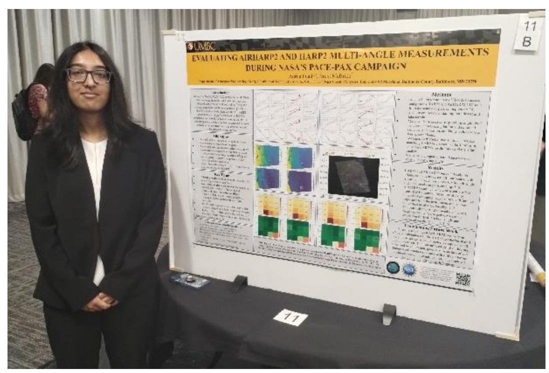
Howard University Beltsville Campus Visit

UMBC 29th Annual Summer Undergraduate Research Fest (SURF)

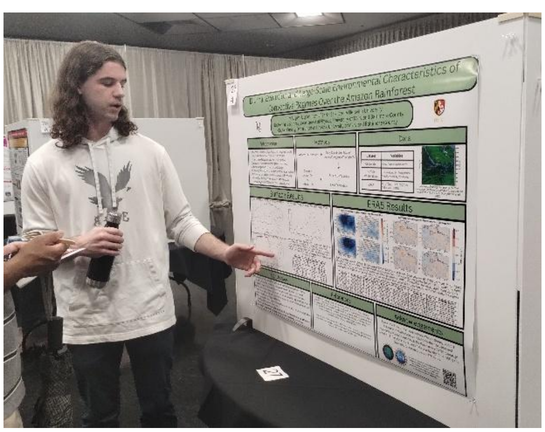




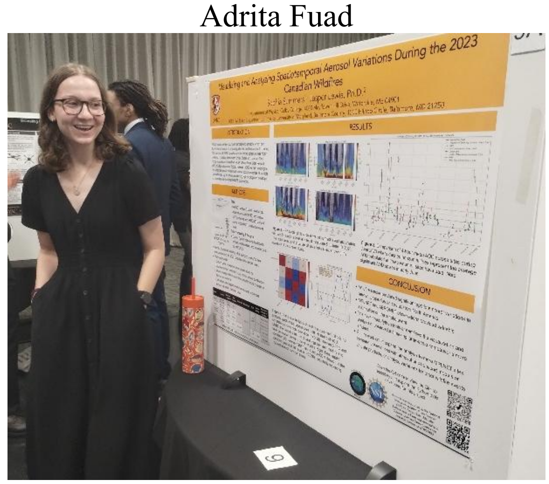
Ashley Nguyen



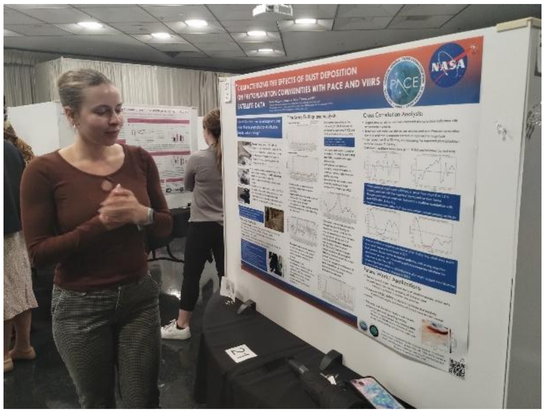
Adrita Fuad



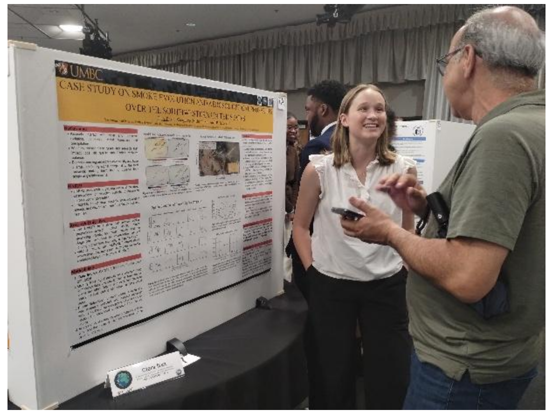
Timothy August



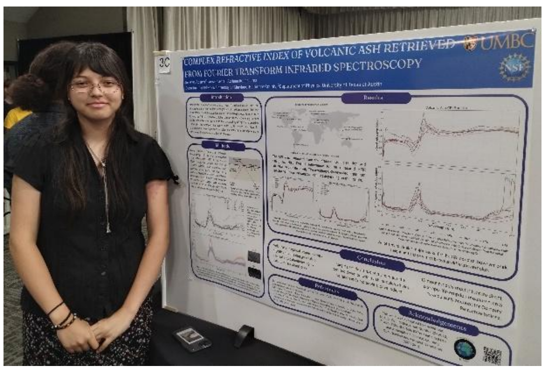
Sophia Summers



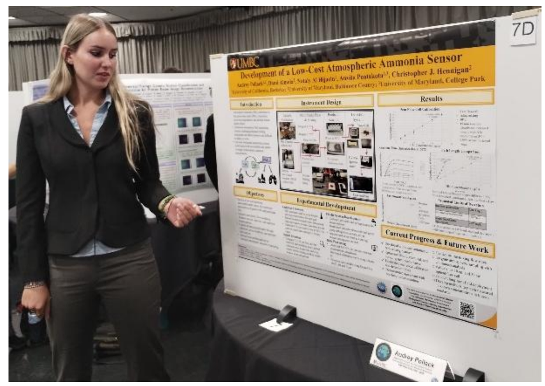
Natalie McCourt



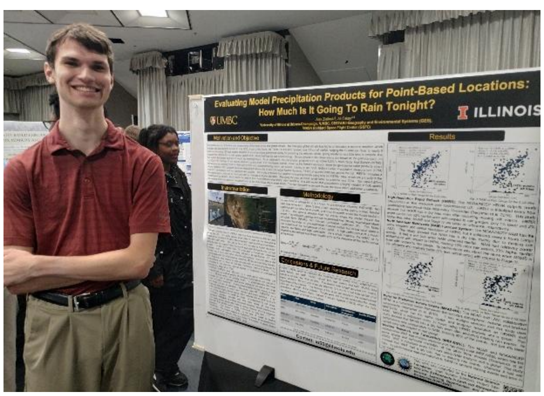
Clara Bax



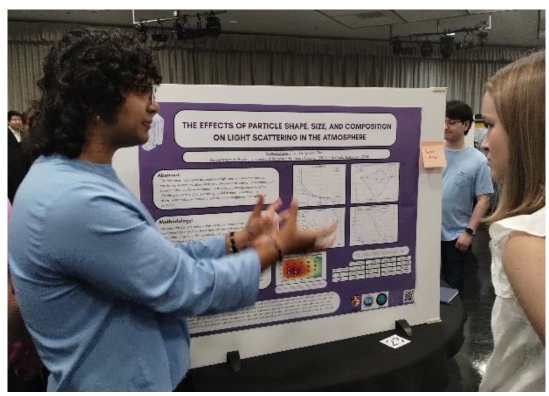
Jo-Dawn Adams



Audrey Pollack



Alex Zielinski



Keenan Anwary

Additional Photos


ZheJiang University Database
Non spherical and inhomogeneous particles
Machine learning
Multiple phase matrix elements
Goddard Space Flight Center
ROMAN
SURF'S UP!
2026
UMBC

2026 NSF REU EXPLORE
Physics Building, Room 401

Agenda Week 1

Sunday, May 31st			
Start Time	**Topic**	**Moderator**	**Duration**
10:00 AM	**Arrival Day**	Adriana Rocha Lima	Full day

Monday, June 1st			
Start Time	**Topic**	**Speaker/Moderator**	**Duration**
9:30 AM	**Coffee & Welcome Reception**	Adriana Rocha Lima Ivona Cetinić Belay Demoz	20 min
9:50 AM	**Welcome from Department Chair**	Matthew Pelton	10 min
10:00 AM	**The Physics of the Atmosphere**	Adriana Rocha Lima	45 min
10:45AM	**Break**		5 min
10:50AM	**Measuring Earth from Air and Space**	Brent McBride	45 min
11:35AM	**Lunch**		
1:30 PM	**AERONET and MPLNET Networks**	Jasper Lewis	45 min
2:15 PM	**Break**		15 min
2:30PM	**From HARP CubeSat to Mega HARP**	Vanderlei Martins	45 min
3:30PM	**Orientation & UMBC Campus Tour**	Adriana Rocha Lima	1:30 hour

Tuesday, June 2nd			
Start Time	**Topic**	**Speaker/Moderator**	**Duration**
9:30AM	**Coffee**		30 min
10:00AM	**Fundamentals of Remote Sensing**	Pengwang Zhai	45 min
10:45AM	**Break**		5 min
10:50AM	**Water Vapor and Clouds on the Climate System**	Henrique Barbosa	45 min
11:35AM	**Lunch**		
1:30PM	**PACE Satellite Products and Science**	Andy Sayer	45 min
2:15PM	**Break**		15 min
2:30PM	**Data Assimilation and Global Atmospheric Models**	Sampa Das	45 min

3:30 PM	**Physics Lab Tours**	Belay Demoz/Jasper Lewis	1:30 hour

(Physics Building - Room 201) Wednesday, June 3rd			
Start Time	**Topic**	**Speaker/Moderator**	**Duration**
9:30AM	**Coffee**		30 min
10:00AM	**The Chemistry of the Atmosphere**	Christopher Hennigan	45 min
10:45AM	**Break**		5 min
10:50AM	**The Science of Precipitation Measurements**	Ali Tokay	45 min
11:35AM	**Lunch**		
1:30PM	**Resolving the Mysteries of Ocean**	Ivona Cetinić	45 min
2:15PM	**Break**		15 min
2:30PM	**Machine Learning, AI, and Science**	Zhibo Zhang	45 min
3:30PM	**The UMBC Grad Experience Exchange**	Grad Students	1 hour

Thursday, June 4th			
Start Time	**Topic**	**Speaker/Moderator**	**Duration**
9:30AM	**Python Bootcamp (Please bring your laptop)**	Joshua Richards	1:30 hour
	Lunch on your own (Suggestion: Peace a Pizza)		
2:30 PM	**Lab Tour - ESI**	Vanderlei Martins	30-45 min
3:30 PM	**Meeting your Mentor (if he/she is available)**		

Friday, June 5th			
Start Time	**Topic**	**Speaker/Moderator**	**Duration**
9:30AM	**EarthData - Pre-Training Cryocloud**	Ivona Cetinić	1:30 hour
11:00AM	**Cryocloud Training - Part 1**	Ian Carroll	1 hour
	Lunch on your own (Suggestion: TBD)		
1:00 PM	**Cryocloud Training - Part 2**	Ian Carroll	1 hour
Afternoon	**Cohort Gathering**		

2026 NSF REU EXPLORE

Agenda Week 2-10

June

Monday	Tuesday	Wednesday	Thursday	Friday	Weekend
8	**9** **3-4 PM: Adriana Rocha Lima's office hour***	**10**	**11** **9:30-11 AM: Python Bootcamp**	**12** **10-11 AM: Ivona Cetinić's office hour ****	**13|14**
15	**16** **12-1 PM REU & Early-Career Social** **3-4 PM: Adriana Rocha Lima's office hour***	**17** **NASA Goddard Space Flight Center – Day Tour Visit**	**18** **9:30-11 AM: Python Bootcamp**	**19** **Holiday!**	**20|21**
22 **9:30-11AM: SEM Training Team 1** **11AM-12:30PM: SEM Training Team 2**	**23** **1:30-3PM: SEM Training Team 3** **3:00 - 4:30PM: SEM Training Team 4**	**24** **9:30 - 11AM: SEM Training Team 5**	**25** **9:30-11 AM: Python Bootcamp**	**26** **10-11 AM: Ivona Cetinić's office hour****	**27|28**
29	**30** **10:00 - 2:00PM NASA Goddard on the Green event** **3-4 PM: Adriana Rocha Lima's office hour***				

*** Tuesdays, 3:00 PM – 4:00 PM: Time reserved for office hours or one-on-one meetings with Dr. Rocha Lima, open to all REU students (in person or online at the Physics Building, Room 425).**
**** Fridays, 10:00 AM – 11:00 AM: Time reserved for office hours or one-on-one meetings with Dr. Ivona Cetinić, open to all REU students (virtually, via Teams).**

July

Monday	Tuesday	Wednesday	Thursday	Friday	Weekend
		1 11:00-2PM: Work-in-Progress Talk Session	2 9:30-11 AM: Python Bootcamp 1:30 - 2:30PM: Ice cream on the Balcony	3 Holiday!	4|5
6	7 3-4 PM: Adriana Rocha Lima's office hour*	8	9 ~~9:30-11 AM: Python Bootcamp~~ Canceled	10 10-11 AM: Ivona Cetinić's office hour**	11|12
13	14 2-4 PM: Adriana Rocha Lima's office hour*	15	16 9:30-11 AM: Python Bootcamp	17 10-11 AM: Ivona Cetinić's office hour**	18|19
20	21 3-4 PM: Adriana Rocha Lima's office hour*	22	23 9:30-11 AM: Python Bootcamp	24 10-11 AM: Ivona Cetinić's office hour**	25|26
27 Beltsville (Howard Univ.) Field Trip 10AM - 3PM	28 1-3 PM: Kavita Mittapalli – NSF REU External Evaluator	29	30 9:30-11 AM: Python Bootcamp	31 10-11 AM: Ivona Cetinić's office hour** Printing poster	Aug 1|2

August

Monday	Tuesday	Wednesday	Thursday	Friday	Weekend
3	4 3-4 PM: Adriana Rocha Lima's office hour*	5 Final Poster – SURF Event - Full Day***	6	7 Departure Day	8|9

More information for the SURF 2026 event will be posted here:
*****Summer Undergraduate Research Fest – UMBC**

2026 NSF REU EXPLORE at UMBC

Agenda
June 17, 2026

NASA Goddard Space Flight Center Tour

Wednesday, June 17th			
Start Time	**Topic**	**Speaker/Moderator**	**Duration**
8:30AM	**Leaving UMBC campus (UMBC shuttle – Commons Drive Loop)**		40 min
9:10 AM	**Arrival at NASA GSFC (Badge Office)**	Ivona Cetinić	
10:00 AM	**Engineering Building Tour**	Gary Davis	45 min
11:00 AM	**Earth Systems Science Building Tour: GSFC In Situ Measurement Laboratory and AERONET**	Jason St. Clair	45 min
12:30 PM	**Lunch**		1 hour
1:30 PM	**Field Support Laboratory**	Crystal Thomas, Austin Grubb	45 min
2:30 PM	**Missions Control Tour**	Valerie Casasanto	45 min
4:00 PM	**Depart NASA GSFC**	Adriana Rocha Lima	30 min
4:30 PM	**Arrival at UMBC**		

2026 NSF REU EXPLORE at UMBC

Agenda
July 27, 2026

Howard University Beltsville Campus Visit

Monday, July 27th			
Start Time	**Topic**	**Speaker/Moderator**	**Duration**
10:15AM	**Leaving UMBC campus (UMBC shuttle – Commons Drive Loop)**		35 min
10:50 AM	**Arrival at Howard University Beltsville Campus**	Adriana Rocha Lima	10 min
11:00 AM	**Introductory Meeting**	Nakul Karle, Ricardo Sakai	45 min
11:45 AM	**Radiosonde Preparation and Launch**	Rocio Rossi, Adrian Flores	45 min
12:30 PM	**Lunch**		30 min
1:00 PM	**Laboratory Tours**	Ricardo Sakai, Adrian Flores, Belay Demoz, David Bernard, Johan Villanueva Medina	45 min
2:30 PM	**Depart Howard University Beltsville Campus**	Adriana Rocha Lima	30 min
3:00 PM	**Arrival at UMBC**		

SURF Abstract

EVALUATING AIRHARP2 AND HARP2 MULTI-ANGLE MEASUREMENTS DURING NASA'S PACE-PAX CAMPAIGN

Adrita Fuad[1], Brent McBride[2]
[1] Department of Aerospace Engineering, Georgia Institute of Technology, Atlanta, GA, 30332
[2] Department of Physics, University of Maryland, Baltimore County, 1000 Hilltop Cir, Baltimore, MD 21250

During the NASA PACE-PAX campaign in fall 2024, PACE satellite data was validated using instruments onboard two aircraft and a ship. Onboard the ER-2 high-altitude aircraft was the AirHARP2 polarimeter, an aircraft version of the HARP2 polarimeter onboard PACE. Validation ensures that PACE and HARP2 are collecting data correctly and that the data can be used to make accurate predictions and observations. Our research aims to see how well AirHARP2 can validate HARP2 by identifying similarities and differences in their collected data. First, we processed HARP2 and AirHARP2 Level 1C data from the same overpass on September 26, 2024, over a scene with both desert and lake terrain. Then, we matched the nearest corresponding single pixel between datasets and extracted radiance, polarization, and degree of linear polarization (DoLP) values across four spectral bands. Since AirHARP2's spatial resolution (~200 m) is far finer than HARP2's (~5 km), we then averaged AirHARP2 pixels into a superpixel matching HARP2's footprint, and compared both datasets using RMSE and Spearman correlation across view and scattering angles. HARP2 and AirHARP2 agreed closely on brightness patterns in both the single-pixel and superpixel results, with Spearman correlations above 0.8. However, AirHARP2 consistently read lower in magnitude, an offset not resolved by superpixel averaging. The near-infrared band showed the clearest disagreement, with a negative Spearman correlation for DoLP. A single-pixel comparison of a separate, primarily ocean scene, without superpixel averaging or statistical analysis, showed visually similar patterns. These results suggest that AirHARP2 is an effective validation tool for HARP2, though the near-infrared DoLP outlier may reflect a calibration issue, a geometric or surface effect, or both. Further studies may explore additional scene types, such as clouds, to determine the outlier's true cause and persistence.

This work was supported by the National Science Foundation, grant number 2349543, project title: REU Site: EXPeriments in Earth and Atmospheric Science: Learning Opportunities and Research Experience (EXPLORE).

EVALUATION OF MODEL PRECIPITATION FOR POINT-BASED LOCATIONS: HOW MUCH IS IT GOING TO RAIN TONIGHT?

Alex Zielinski[1], Ali Tokay[2,3], Charles N. Helms[3,4], Stephen D. Nicholls[3,5]
[1] Department of Climate, Meteorology, and Atmospheric Sciences, University of Illinois at Urbana-Champaign, Urbana, IL 61801
[2] GESTARII and Department of Geography and Environmental Systems, University of Maryland Baltimore County (UMBC), Baltimore, MD 21250
[3] NASA Goddard Space Flight Center, Greenbelt, MD 20771
[4] ESSIC, University of Maryland, College Park, MD 20740
[5] Science And Technology Corporation (STC), Columbia, MD 21046

Gauge-adjusted and radar-based precipitation products such as MRMS and Stage IV are heavily used to verify model precipitation products, as they provide precipitation mapping across the US. Their accuracy at a given location primarily depends on the data availability and quality. MRMS and Stage IV are comparable to each other, missing about 10% of rain events and 18-44% errors in rainfall totals. NASA's Global Precipitation Measurement Ground Validation (GPM-GV) program has been deploying Platforms for In-Situ Estimation Rainfall Systems (PIERS) at various locations across the US. This study uses nine (9) PIERS+ sites, which include a PARSIVEL disdrometer and dual tipping bucket gauges, for the calendar year of 2024. The sites are primarily in the Mid Atlantic, with two sites in Texas and one in Colorado. The PARSIVEL disdrometer defined the events, event duration, and mean and maximum rainfall, while the tipping bucket gauge was the reference for rainfall amount. Unlike previous validation studies where a fixed time scale was selected, this study focuses on event rainfall for evaluating the performance of four models: the High Resolution Rapid Refresh (HRRR) model, the North American Mesoscale (NAM) model, the National Severe Storms Laboratory Model for Prediction Across Scales (NSSL-MPAS) model, and the National Severe Storms Laboratory Weather Research and Forecast (NSSL) model. These models all provide hourly forecasts but vary in spatial resolution and model initiation. PIERS+ is not part of any operational algorithm and therefore provides independent evaluation. This study follows a farmer's approach, meaning that it does not investigate the model production stage. Preliminary results indicate the HRRR underestimated rainfall by about 25%, an average error of 53%, and missed 25% of the events. The NAM underestimated rainfall by about 10%, with an average error of 72%, and missed 40% of the events.

This work was supported by the National Science Foundation, grant number 2349543, project title: REU Site: EXPeriments in Earth and Atmospheric Science: Learning Opportunities and Research Experience (EXPLORE).

CLASSIFYING MINERAL DUST USING AEROSOL PROPERTIES FROM PACE OBSERVATIONS

Ashley Nguyen[1,2], Zhibo Zhang[2]
[1] College of Computing, Data Science, and Society, University of California, Berkeley, CA 94720
[2] Department of Physics, University of Maryland, Baltimore County, 1000 Hilltop Circle, Baltimore, MD, 21250

Mineral dust aerosols play an important role in modulating atmospheric processes and the Earth's energy budget by scattering and absorbing shortwave and longwave radiation. Accurately distinguishing them from other aerosol types using satellite observations remains challenging because of their variability in size and shape and atmospheric mixing. In this study, we examine dust-concentrated and dust-smoke mixture events from regions surrounding Northern Africa and North America. To begin, data products are queried from NASA's PACE (Plankton, Aerosol, Cloud, ocean Ecosystem) instruments: Ocean Color Instrument (OCI) and Hyper Angular Rainbow Polarimeter (HARP2). Comparing these instruments allows us to answer how geographic regions, atmospheric composition, or viewing geometry report differences in optical properties, as well as which retrieval variable best separates dust-like from non-dust scenes. OCI Unified Aerosol Algorithm Aerosol Optical Properties (UAAAER) are then collocated to match a common grid with HARP2 Fast Multi-Angle Polarimetric (FastMAPOL). Since HARP2 FastMAPOL only has ocean retrievals, this study focuses on events over marine regions. We then developed a K-means clustering algorithm to quantify aerosol clusters, explain internal properties, and identify feature importance. An initial run of the OCI UAAAER and HARP2 FastMAPOL cluster analysis using Angstrom Exponent and Aerosol Optical Depth features for the Saharan Dust Transport resulted in silhouette scores of 0.538 and 0.457, respectively. While both instruments have three moderately well-defined clusters, OCI UAAAER showed clearer distinctions among clean sky, severe sandstorms, and moderate smoke/dust loading, supported by the centroid points. HARP2 FastMAPOL clusters grouped more closely, with a clear indication of intense sandstorms but vagueness in other potential aerosols. This study is still underway, with opportunities to add more temporal and spatial data containing a mixture of dust, smoke, and other aerosols, validate with in-situ observations, and select additional optical features to better distinguish aerosol types.

This work was supported by the National Science Foundation, grant number 2349543, project title: REU Site: EXPeriments in Earth and Atmospheric Science: Learning Opportunities and Research Experience (EXPLORE).

DEVELOPMENT OF A LOW-COST ATMOSPHERIC AMMONIA (NH3) MEASUREMENT SYSTEM

Audrey Pollack[1,2], Dami Aimola[2], Nataly Al Hijazin[2], Anvita Pentakota[2,3], Christopher J. Hennigan[2]

[1] Department of Environmental Science, Policy, and Management, University of California, Berkeley, 110 Sproul Hall, Berkeley, CA 94720

[2] Department of Chemical, Biochemical, and Environmental Engineering, University of Maryland, Baltimore County, 1000 Hilltop Circle, Baltimore, MD 21250

[3] Department of Chemical and Biomolecular Engineering, University of Maryland, College Park, 7901 Regents Drive, College Park, MD 20742

Atmospheric ammonia is an important air pollutant that contributes to fine particulate matter formation, ecosystem degradation, and adverse human health effects. Continuous monitoring of atmospheric ammonia remains challenging because existing instrumentation is often expensive and difficult to deploy at scale. To address this limitation, our team is developing a low-cost automated spectrophotometric sensor capable of continuously measuring gaseous NH3 and particulate NH4+. Measuring both phases separately further provides insight into ammonia partitioning which is critical for characterizing aerosol thermodynamics. The system integrates automated sampling, microfluidics, Berthelot colorimetric chemistry, and UV-Vis spectroscopy to quantify atmospheric NH3 and NH4+ concentrations. Our research focuses on optimizing reaction conditions, microfluidic flow systems, and analytical instrumentation while generating calibration curves and evaluating instrument performance using OceanView and MATLAB. This work aims to improve instrument sensitivity, accuracy, and detection limits while advancing accessible, continuous atmospheric chemistry measurements.

This work was supported by the National Science Foundation, grant number 2349543, project title: REU Site: EXPeriments in Earth and Atmospheric Science: Learning Opportunities and Research Experience (EXPLORE).

CASE STUDY ON SMOKE EVOLUTION AND AEROSOL OPTICAL PROPERTIES OVER THE SOUTHWESTERN UNITED STATES

Clara Bax[1,2], Xiaoguang (Richard) Xu[1], Anin Puthukkudy[1]
[1] Department of Physics, Earth and Space Institute, University of Maryland, Baltimore County, 1000 Hilltop Circle, Baltimore, MD 21250
[2] Department of Atmospheric and Oceanic Sciences, University of Colorado Boulder, 914 Broadway, Boulder, CO 80309

Increased wildfire activity in the southwestern United States impacts air quality, human health, and Earth's radiative balance. NASA's PACE HARP2 instrument uses multi-angle, multi-spectral polarized observations of reflected sunlight to determine aerosol optical properties. These properties provide key information about aerosol concentration, size, and composition, which can help improve air quality forecasts and public health alerts. This project aims to analyze four different aerosol optical properties—aerosol optical depth, single scattering albedo, fine mode fraction, and the Ångström exponent—from six wildfires that occurred on June 29, 2026. Given the spatial and temporal similarities, the evolution of aerosol optical properties across the smoke plumes was expected to be similar. Using RGB imagery, six distinct plumes were mapped, with a cross-section and bounding box identified for each. Then, quality-controlled pixels within 7.5 km of the cross-section were analyzed to understand the optical properties of each plume. Pixels near the fire source are often flagged and excluded because heavy aerosol loading from biomass burning can cause a false cloud mask; thus, only five of the six plumes were analyzed. Each of the five plumes studied exhibited aerosol optical depth that peaked near the source and decreased with distance. The Ångström exponent generally exceeded 1.5 near fire sources, indicating the presence of fine-mode aerosols, commonly associated with biomass burning. Single scattering albedo and aerosol loading values varied between plumes, suggesting differences in combustion mode, fuel type, particle size, and dispersion behavior. These results demonstrate that regional smoke evolution does not follow a single pattern, emphasizing uncertainties in observing wildfire smoke development and measuring aerosol optical properties, which complicates air quality forecasts and public health alerts.

This work was supported by the National Science Foundation, grant number 2349543, project title: REU Site: EXPeriments in Earth and Atmospheric Science: Learning Opportunities and Research Experience (EXPLORE).

COMPLEX REFRACTIVE INDEX OF VOLCANIC ASH RETRIEVED FROM FOURIER TRANSFORM INFRARED SPECTROSCOPY

Jo-Dawn Adams[1,2], Ansel Lavitz[1], Adriana Rocha Lima[1]
[1] Department of Physics, University of Maryland, Baltimore County, UMBC, 1000 Hilltop Circle, Baltimore, MD 21250.
[2] Department of Physics, University of Texas at Austin, 2515 Speedway, Austin, TX 78712.

Around 50-70 volcanoes erupt each year, releasing ash into the atmosphere that can reflect sunlight and, in extreme cases like the 1991 Mount Pinatubo eruption, cause the average global temperature to cool by 1°F. However, global climate models generally do not predict the effects of ash from eruptions due to the uncertainty of optical properties, especially the Complex Refractive Index (CRI). Deriving CRI is critical for understanding how light interacts with particles in the atmosphere, which drives weather patterns and Earth's climate. This project aims to establish an optical baseline that can improve upon the predictive abilities of global climate models to ensure that radiative effects of volcanic ash are accurately simulated based on measured properties rather than generalized approximations. We used Fourier Transform Infrared Spectroscopy (FTIR) with Attenuated Total Reflectance (ATR) in the 2.5µm-25µm range to derive the CRI of distinct volcanic ash samples. Original and crushed ash samples were placed on top of a diamond crystal to achieve the total internal reflectance necessary for ATR, which was sensitive to particle size. Larger particles were crushed to reduce heterogeneity at the interface between sample and crystal. The CRI was estimated from the Kramers-Kronig relation and fitting modelled Fresnel reflectance to the measured FTIR absorbance data iteratively. The resulting CRIs revealed significant spectral variations among the samples depending on their origin. Integrating these volcanic ash optical properties into climate models may lead to more accurate simulations of ash radiative effects.

This work was supported by the National Science Foundation, grant number 2349543, project title: REU Site: EXPeriments in Earth and Atmospheric Science: Learning Opportunities and Research Experience (EXPLORE).

THE EFFECTS OF PARTICLE SHAPE, SIZE, AND COMPOSITION ON LIGHT SCATTERING IN THE ATMOSPHERE

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Since its inception, NASA has launched over 60 satellites dedicated to Earth observation. The data collected from these satellites is used to support numerous fields of research, including, but not limited to, meteorology, biology, and geography. In order for all of this data to be used effectively, we must interpret satellite measurements with physics models of light-matter interaction, i.e., light scattering theory. The fundamental physics parameters in light scattering include scattering extinction, absorption, and efficiency, phase matrix, and albedo. The Mie scattering model is well researched and documented and is a very valuable tool in showing the effects of refractive index and size parameters in the aforementioned scattering parameters, but it is only applicable to spherical objects. We must then find ways to model light scattering by nonspherical particles, for example, the recently published ZheJiang University's (ZJU) database of scattering of a large range of particle shapes. The ZJU scattering model uses more sophisticated techniques such as the invariant imbedding T-matrix method, to create a prediction-based model that can handle inhomogeneous groups of aerosol particles and ice. Using this in python models with volume size integration techniques, we are able to model a collection of different sized and shaped particles to see what their scattering parameters would look like. This will allow us to predict the chemical composition , shape, and the size of the aerosols by comparing the data received from space to our predictions. We do this in order to better understand and model Earth's ever-changing atmosphere.

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CHARACTERIZING THE EFFECTS OF DUST DEPOSITION ON PHYTOPLANKTON COMMUNITIES WITH PACE AND VIIRS SATELLITE DATA

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Understanding the drivers of phytoplankton distribution, diversity and physiology is complex yet essential for improving our understanding of the carbon cycle. Dust storms deposit massive quantities of iron into the ocean, a key and limiting micronutrient for phytoplankton globally. This study evaluated the relationship between the occurrence and intensity of significant dust events and changes in phytoplankton physiology and community composition, focusing on the Atlantic off the coast of Patagonia and over regions of the Mediterranean Sea. Conducted to increase the scope of current understanding of how dust events impact ocean ecosystems, we performed time series analyses of remote sensing products including dust aerosol optical depth (AOD), sea surface temperature (SST), sea surface temperature anomaly (SSTA), chlorophyll concentration, phytoplankton biomass (carbon_phyto), fluorescence line height (nflh), and PACE's phytoplankton community composition product (MOANA), which estimates the relative abundance of picophytoplankton groups. Lag correlation analyses were used in order to characterize the temporal relationship between dust events and biological responses, identifying time lags for which correlations were strongest and statistically significant. Preliminary results indicate a 10-15 day lag between dust event occurrence and peaks in chlorophyll concentration, phytoplankton biomass, chl:carbon ratio, and nflh for both locations, as well as significant negative correlations between SST and biomass. Results also indicate that picoeukaryotes, and Synechococcus, and Prochlorococcus exhibit distinct temporal responses to dust events, suggesting group-specific sensitivities to atmospheric dust deposition.

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VISUALIZING AND ANALYZING SPATIOTEMPORAL AEROSOL VARIATIONS DURING THE 2023 CANADIAN WILDFIRES

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Wildfires are a major source of atmospheric aerosols, which can have many impacts on air quality, climate, and human health. During the summer of 2023, Canada saw an increase in wildfire events which led to the transport of smoke across much of Eastern North America. Using observations from the Micro Pulse Lidar Network (MPLNET) and the co-located Aerosol Robotic Network (AERONET), this study investigates the spatiotemporal variability of aerosol optical properties at multiple sites affected by the smoke event. To improve accessibility and analysis of MPLNET data, Python programs were developed to retrieve, quality screen, and visualize lidar observations. These tools allow for efficient comparison of aerosol properties across multiple locations and time periods through the generation of maps, curtain plots, time series, average profiles, and correlation analyses. These observations were used to investigate changes in aerosol properties, like aerosol optical depth (AOD) and extinction, to illustrate the difference between aerosol loading and vertical structure across the sites. These results provide insight into the transport and variability of aerosols resulting from regional events such as wildfires and contribute to improved understanding of aerosol distributions relevant to atmospheric modeling and remote sensing applications.

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DIURNAL EVOLUTION OF CLOUD FRACTION AND SURFACE METEOROLOGICAL VARIABLES ACROSS CONVECTIVE REGIMES OVER THE AMAZON RAINFOREST

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The Amazon rainforest plays a key role in the global climate cycle, releasing moisture into the atmosphere and influencing rainfall patterns across South America and beyond. Due to the region's complex atmospheric processes, tracking and understanding convection remains a challenge. Using data from the GoAmazon 2014-15 field campaign, we investigate how cloud properties, surface meteorological conditions, and the large-scale environment differ among shallow, congestus, deep, and mesoscale convective system (MCS) regimes. Ceilometer measurements, surface observations, and ERA5 reanalysis were combined to examine whether large-scale environmental conditions are already established prior to shallow and deep convection. A fog indicator was also developed utilizing both ceilometer and surface-based observations to investigate low level cloud and fog occurrence. Cloud classifications were assigned based on a pre-existing daily convective regime classification method. Deep and MCS days exhibited higher cloud fraction as well as higher relative humidity, precipitation rate, and dewpoint temperature, while shallow and congestus regimes exhibited higher surface temperatures and boundary layer heights. ERA5 composites indicate deeper regimes are associated with greater total column water vapor and total column liquid water, as well as lower cloud base and planetary boundary layer heights. These ERA5 composites suggest that many large-scale environmental differences are already present on the day preceding shallow and deep convection.

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