Questions & Answers Part 1

Please type your questions in the Question Box. We will try our best to get to all your questions. If we don't, feel free to email Carl Malings (carl.a.malings@nasa.gov) or Susan Anenberg (sanenberg@email.gwu.edu).

Question 1: Are there more opportunities to join EJ activities via NASA FINESST?
Answer 1:The NASA FINESST (Future Investigators in NASA Earth and Space Technology) proposal opportunities are offered yearly through the NASA NSPIRES site: https://nspires.nasaprs.com/external/
The FINESST program is divided between five programs: Astrophysics, Earth Science, Heliophysics, Planetary Science, and Biological and Physical Sciences.

Question 2: How are the poorly data covered regions analyzed? What is the resolution of the data?
Answer 2: Regions which are poorly covered by traditional measurement and monitoring methods (such as having ground-based sensors which may be sparsely placed -such as in rural areas, not functioning optimally, and/or placed with bias) can be analyzed using direct or indirect satellite data at different resolutions, depending on the environmental condition examined. Higher resolution data which has become more available in recent years, for example at a resolution of 1 km x 1 km to examine $PM_{2.5}$, is beneficial for advancing EJ. Researchers who conducted environmental epidemiological studies while investigating air pollution disparities described how high spatial resolutions of 1 km x 1 km plus full geographic coverage are valuable for examining neighborhood-scale health impacts in those areas where low-cost sensor networks and mobile monitoring data may not exist. Castillo et al. (2021) used the North American satellite derived data set (V4.NA.03) at 1 km x 1 km. Other examples from the studies we found include:

TROPOMI examines the environmental variable NO_2. It provides daily global coverage (2018-present) at a resolution of **3.5 km x 5.2 km**.

Di et al. (2020) developed a satellite dataset (2000-2016) to examine NO_2 which covers the continental U.S. at **1 km x 1 km.**

MODIS Terra Land Surface Temperature and Emissivity (2000-present) examines climate on a global scale at **1 km.**

For examining the built environment, satellites cover a wide range of resolutions:

Landsat 2 (1975-1983) provides global coverage at an 80 m scale, but Landsat 7 (1999-2022) allows better examination as it provides global coverage at a 30 m scale.

MODIS Terra, which examines globally (1999 – Present) on a 250 m scale (1-2 days with composite images every 16 days), was used by many of the researchers we reviewed. For example, Son et al., (2021) examined modeled $PM_{2.5}$ using MODIS Terra.

Mitchell and Chakraborty (2014), whose research is entitled "Urban Heat and Climate Justice: A Landscape of Thermal Inequity in Pinellas County, Florida," also used MODIS Terra, but instead of examining air pollution inequities, they examined thermal inequities.

More info on MODIS Terra: https://terra.nasa.gov/about/terra-instruments/modis#:~:text=Moderate%20Resolution%20Imaging%20Spectroradiometer&text=Consequently%2C%20MODIS%20tracks%20a%20wider,by%20clouds%20almost%20every%20day

Question 3: Where can I find data on light at night?

Answer 3: Here is a website describing the data:
https://www.earthdata.nasa.gov/learn/backgrounders/nighttime-lights
https://appliedsciences.nasa.gov/get-involved/training/english/arset-introduction-nasas-black-marble-night-lights-data
An earlier ARSET Training has covered this dataset as well: Introduction to NASA's "Black Marble" Night Lights Data
County- and tract-level light at night data (2012-2020) are available at
https://disc.gsfc.nasa.gov/information/data-release?title=NASA%20HAQAST%20Annual%20Summary%20of%20Artificial%20Light%20At%20Night%20from%20VIIRS%2FS-NPP%20at%20CONUS%20County%20and%20Census%20Tract%20Version%201%20Product%20Released%20to%20Public

Question 4: What is the size of the sample population from which these associations derived? (LAN)

Answer 4: The analysis included all census tracts in the contiguous US. Details of the analysis can be found in our published paper: https://doi.org/10.1016/j.envint.2023.108096

Question 5: Economic literature points at a positive relationship between economic development and Nighttime lights. Do you think this might also explain the results?

Answer 5: There is indeed a well-established positive relationship between light at night and GDP, which we also noted in our county-level analysis of ALAN in the US (link to preprint: https://www.researchsquare.com/article/rs-2883384/v1). However, I don't believe the observed relationship between ALAN and SVI was fully explained by the relationship between ALAN and GDP. This is because the results remained largely similar after we accounted for clustering at the county level and/or controlled for county level GDP specifically. We believe other factors beyond economic development may have contributed to these patterns. We discussed several potential contributing factors in the Discussion section of our paper: https://doi.org/10.1016/j.envint.2023.108096

Question 6: Instead of using SVI, was there any thought of using the Community Resilience Estimate? https://www.census.gov/programs-surveys/community-resilience-estimates/data/datasets.html

Answer 6: The brief answer is yes. One of the things our study revealed is the complexity of the relationship between night light and different domains of social vulnerability. We anticipate that a different methodology in measuring social disadvantage at the community level may have an impact on this relationship, and it is of interest to study the distribution of night light in relation to different measures of community vulnerability and resilience to gain insight into the causes of ALAN injustice in American neighborhoods.

Question 7: Which satellite measures $PM_{2.5}$? Will there be access to a high resolution $PM_{2.5}$ dataset for Africa?

Answer 7: I used a secondary dataset that uses satellite observations of Aerosol Optical Depth (AOD), ground-based observations and an atmospheric model to estimate $PM_{2.5}$ at $1km^2$ resolution. This dataset was developed by the Atmospheric Composition Analysis Group at Washington University in St. Louis. There are versions of this dataset available globally and

for different regions. The dataset is located here - https://sites.wustl.edu/acag/datasets/surface-pm2-5/

Question 8: A broad question for all of the presenters, can you explain more about your decision on choosing the particular satellite data or product that you ended up using - ie. the pros and cons vs. other datasets. Just a secondary thought that nobody seems to be using geostationary satellite data.

Answer 8: There are many factors which can influence this choice in general. We will be discussing this (including the use of geostationary datasets) in the context of air quality data in Part 2 of this training on August 30, 2023, discussing the benefits and limitations of different satellite data products relevant for air quality.

In the case of the NASA-funded project that is a collaboration between MIT and the government of Angola, we hope to use a variety of datasets that are relevant to understanding how drought is impacting low-income communities and how their socioeconomic experience impacts their vulnerability to drought. We seek datasets that can help the government determine which municipalities need short term and long term assistance. We will need a variety of satellite-based and administrative dataset. Typically, data from low-earth orbit satellites will be helpful because it has higher spatial resolution than geostationary data. (-Danielle Wood)

The reason that I am interested in using satellite data to measure ALAN is because my main research interest focuses on both the health consequences and environmental determinants of sleep deficiency and circadian disruptions at the population level. Satellite data offer a great opportunity for characterizing ALAN (mostly outdoor light) with great geographic and temporal coverage and resolution, which are important for epidemiological studies. (-Qian Xiao)

Question 9: Equity and EJ are often associated with race or the "poor." However, many households are Asset Limited, Income Constrained, Employed (ALICE). they are above the "poverty level," but struggle to pay the bills. These are the "working Poor." Is anyone looking at EJ for ALICE populations? Spatial data available at: https://www.unitedforalice.org.

Answer 9: Thanks for raising this important question; none of the studies we found used ALICE. In searching for studies to include in our SD4EJ Scoping Review, we found that the majority of authors reporting on U.S. based research use well-recognized or government-recognized measures of income/poverty and less measures based on a variety of possible indicators of such status or other "asset limited" indicators, which would have been interesting to document as evidence of differences which impact environmental justice. Some U.S.-based study authors used subsidized housing, school-children receiving free meals, and Medicaid eligibility to determine income/poverty/SES indicators. Some authors did use indicators like automobile ownership or "rent vs own" to determine SES status. In contrast to U.S.-based studies, many of the authors of the international-based research we found (which we excluded as part of our criteria) did incorporate other measures in describing differential exposure or differential vulnerability. For example, in "Is air pollution worsening as communities get poorer in Mexico? Long-term Evidence from Satellite Imaging Data," researchers Lopamudra Chakraborti and John Voorheis (2021) used satellite derived municipality level average exposure to $PM_{2.5}$ pollution data from 2001 to 2015 (from Hammer et al., 2020) combined with income, low SES, Indigenous population, and racial/ethnicity data to determine if certain communities (Indigenous people households) were disproportionately exposed to air pollution. However, due to the lack of the type of U.S. income/poverty/SES data available in Mexico, they used different socioeconomic status variables, such as percent of households without basic infrastructure - such as piped water and electricity - or the household's percent of school-aged children not enrolled. In Kuffer et al.'s study, "Capturing the Urban Divide in Nighttime Light Images From the International Space Station," which investigated Dar es Salaam, Mumbai, Ahmedabad, and Belo Horizonte, the authors aimed to investigate the capacity of International Space Station images in addressing urban inequity EJ concerns regarding access to nighttime light (NTL) for safety and transportation issues. They used the satellite images taken on the ISS, which are available through 'The Gateway to Astronaut Photography of Earth' to examine the intra-urban divide. They combined NTL data with a variety of land-use, roads, buildings, and slums data. Deprived areas are less economically developed than non deprived areas, and inhabitants of such areas are of lower SES and often face poverty. This study was different from U.S. based studies because it did not assess inhabitant SES or race/ethnicity characteristics but used land-use data instead. Several other studies we found were based in various countries of Africa, which used land-use, land-cover change, assets of land/crops/livestock owned, quality of housing, amounts of rent paid to landlord and other

indicators of difference rather than quantitative income/poverty status indicators (especially in cases of environmental justice related to climate change in agricultural/rural areas). A study by Wong et al., 2016, "Spatially analyzing the inequity of the Hong Kong urban heat island by socio-demographic characteristics," used data on occupations of groups of workers and education attainment rather than income/poverty indicators. They used high resolution satellite data (Landsat 5 TM) and found that low SES is associated with detrimental UHI health impacts in Hong Kong.
If you are interested in using measures like ALICE in your own research, hopefully you will be able to use the things you will learn during this training series to implement your own analysis.

Question 10: LAN may not be considered as a factor in the Nigerian context due to poor power supply at Night. However, could there be any Environmental Justice due to lack of LAN?
Answer 10: That's a very interesting question! Yes, there could very well be environmental justice issues (or other equity concerns, especially access to electricity) associated with access to electricity which could be investigated using Light at Night data; see the answer to question 5, above.

Question 11: What is the full citation of the article by Dr. Carrión?
Answer 11: The article can be found here: https://doi.org/10.1016/j.envres.2021.111477

Question 12: How could this data gap improve in an investigation where I use satellite images and due to cloud coverage in mountainous areas, I have very few valid satellite data, for instance, for AOD?
Answer 12: Lack of data due to cloud cover is indeed a limitation of satellite data. Using multiple satellite datasets, including geostationary data which allows for multiple observations per day, can allow finding sufficient gaps between cloud cover to get valid information. Averaging satellite data records for longer periods of time can help to find more cloud-free data. However, there are no guarantees, and there can certainly be limitations in satellite data coverage due to persistent cloud cover. Combining satellite data with model outputs, which help to fill in any gaps in satellite data, is another approach. We will discuss this more in Part 2 of this training on August 30, 2023.

Question 13: What are some examples of reflective surfaces that may interfere with satellite data?
Answer 13: Water, snow, ice, and sandy deserts are examples of natural reflective surfaces. In urban areas, metals and glass can create reflective surfaces.

Question 14: Can we quantify air pollutants using satellites?
Answer 14: Yes, certain pollutants can be identified using satellite data, including NO_2, CO, SO_2, and aerosols. It's important to note that satellites are quantifying the concentrations of these pollutants in the full atmospheric column, not just at the surface level (which is most relevant to air quality). We will discuss this in more detail in Part 2 of this training on August 30, 2023.

Question 15: Can you share whether there is any NASA data available on methane and any associated mapping efforts?
Answer 15: Yes, there are several NASA (and other) satellite missions aimed at detecting methane. We will discuss some of these briefly in Part 2 of this training on August 30, 2023. Here is an overview webpage: https://climate.nasa.gov/vital-signs/methane/

Question 16: Are there any specific challenges in using satellite data for air quality monitoring in urban areas compared to rural areas?
Answer 16: Yes, there are several challenges, including the high variability in land surface cover and reflectivity in urban areas compared to rural ones. We will be discussing this some more in Part 2 of this training on August 30, 2023. For our SD4EJ Scoping Review, we found it interesting that some researchers found that NO_2 exposure and mortality among Medicare beneficiaries in the Southeast US were more pronounced in urban areas than in rural areas, while another set of researchers found that an association between $PM_{2.5}$ exposure and mortality among Medicare beneficiaries in North Carolina and Michigan were higher in rural areas compared to urban areas.

Question 17: Tropomi es de Acceso abierto, y uno puede ver niveles de Sud-américa? [Translation: Tropomi is Open Access, and one can see levels from South America?]
Answer 17: That's correct, TROPOMI data are open-access (and can be accessed through NASA's data portals via an agreement with the European Space Agency). TROPOMI provides global coverage, including over South America. We will discuss TROPOMI in more

detail, including showing an example of accessing the data, in Part 2 of the training on August 30, 2023.

Question 18: How are the figures made in the presentation? (which software or tool)
Answer 18: Several of the graphs in Susan's presentation were made using Python, and we will use Python to explore air pollution injustice using satellite data in Session 3. Any programming language can be used - R, Matlab, etc. GIS software is also often used to generate maps and analysis. Google Earth Engine is another great resource to use, and already has easy access to some satellite data.

Question 19: Do you have examples of how this information has affected policy decisions?
Answer 19: Satellite data, in combination with other data, can have impacts at community, agency, and policy levels, but satellite data has to be more widely recognized by a variety of actors as providing scientific-evidence which is easily accessible and understandable by diverse audiences and users in order to have greater impact. Satellite data can stimulate policy reform as, for example, they 1) identify locations and populations at risk, 2) identify locations in which regulators should put more in-situ monitoring of an environmental condition (such as air pollution or temperature/urban heat), 3) identify locations where other measuring/monitoring devices are sparsely placed or unevenly situated. Satellite data could inform urban/city planning decisions (such as land-use) and community planning decisions (such as where to plant more trees or where to place more monitors). One example is a municipal government who used satellite-derived air pollution estimates and associated health risks to determine where to deploy electric buses, with the aim of improving air quality for overburdened communities. More broadly, satellite data can be used by combinations of environmental justice actors - public health practitioners, city planners, mayors, social justice activists, racial/ethnic community nonprofit leaders/reps - to help harness support for policy reform. Community organizations with access to satellite data could send community health workers to those neighborhoods which demonstrate higher exposure to environmental hazards, for example to help with self-management of asthma and to reduce asthma related hospitalizations/emergency department visits. Currently, governmental agencies are not required to use satellite data for their various EJ related actions, but some do. For example, the U.S. Environmental Protection Agency has used satellite data in their Air Trends Report and to assess exposure and risk as part of the process for setting National Ambient Air Quality Standards. In our scoping review, we will provide

more concrete examples of how satellite data can stimulate policy reform and community interventions (as we require both top-down and bottom-up approaches to make a difference). By harnessing support from diverse actors/sectors at multiple levels, satellite data can be the evidence necessary to propel policymakers to pay more attention to the problem of environmental injustice. To summarize, we are just at the beginning of seeing satellite data being applied in policy contexts to improve environmental justice. If you have other examples, consider posting them in the https://haq.community.forum/ so others can learn about them!

Question 20: Will intercalibration results be provided for combining multiple types of satellite data?

Answer 20: Generally these types of results are published in academic papers which discuss the methodologies used to create these multi-satellite or multi-data-source products. For example, the Atmospheric Composition Analysis Group webpage includes links to papers describing the methodology used to create the different datasets, as well as validation results. NASA SEDAC also provides references for its datasets.

Question 21: I am working for WFP Ethiopia as a GIS officer. We are currently expecting heavy rains in the coming month due to EL nino, does ARSET produce hazard mapping for humanitarian agencies?

Answer 21: Our Online Resource Guide contains information about our previous trainings. We have done a number of trainings on floods and disasters you might like to review, for example: https://appliedsciences.nasa.gov/get-involved/training/english/arset-monitoring-and-modeling-floods-using-earth-observations.

Question 22: [Sorry to be blunt] What are the academic or EJ advantages of (other than being low-cost) using these 1km x 1 km data that produce coarse results in the face of the next-generation Airbus images that have something like 30 cm or 50 cm resolutions, which are extremely expensive?

Answer 22: Open access, freely available information is incredibly important when it comes to connecting scientific research and communities, particularly in the context of environmental justice. In some cases, higher resolution may not necessarily be "better" since people move throughout the day and are exposed to air pollution wherever they go. Furthermore, higher resolution datasets require more storage space and processing power to

analyze. Also, certain geophysical quantities (e.g., trace gas concentrations) require hyperspectral information which are not yet available at such resolutions. However, it may be that for certain issues such a high resolution is necessary, and the more information the better we understand the problem and can address it.

Question 23: Pretty broad question and it will certainly depend on specifics and needs (possibly covered in later sessions): what software do you typically use for managing and analyzing remote sensing data? My experience is largely with ESRI products but I recognize there are better tools out there when working with remote sensing data.
Answer 23: Many people use Python, R, and Google Earth Engine. But any programming language can be used, and GIS can also be a helpful tool for mapping. We will be providing an example using Python in Part 3 of this training on September 6, 2023.

Question 24: What is the best Applied Sciences program contact that could help a federal agency assess the feasibility of incorporating satellite data in their environmental justice impact studies? Are there interagency capacity building programs?
Answer 24: The NASA DEVELOP program partners with organizations (including federal agencies) seeking to use Earth observation data to support their decision-making needs. Selected project teams of 4-5 people conduct 10-week projects in collaboration with DEVELOP science advisors and mentors to apply Earth observations to address their specific need; the results of these projects can then serve as a template for future developments. NASA ARSET also provides capacity building for other federal agencies, e.g., a recent in-person training for US EPA. You might also search through the list of Applied Science team members, or email the trainers directly and we will help put you in contact with someone who can help you.