EARTH SCIENCE APPLICATIONS WEEK 2022

Day 1: Environmental Justice & Urban Development

August 9, 2022
WELCOME!

DAY 1 – AUGUST 9th: ENVIRONMENTAL JUSTICE & URBAN DEVELOPMENT

Event Attendance Guidelines
1. Please stay muted with cameras off
2. Post questions for speakers in the chat & they will be answered there
What is Environmental Justice?

Environmental Justice (EJ) is “the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies.”

Map of Washington, D.C., showing areas that have higher rates of PM2.5-attributable mortality.

Elevated rates of PM2.5-attributed mortality correlate with areas that have a higher proportion of Black residents.

Credit: NASA Earth Observatory.
What can NASA do?

**Satellite data can help us uncover environmental injustices**

- **Monitor restoration of electricity** in rural Puerto Rico following Hurricane Maria, which found that rural areas were disproportionately impacted by prolonged power outages.

- Pair sea surface height with demographic data for Norfolk, Virginia to understand disparities seen by communities of color and lower economic status in negative impacts of **sea level rise**.

- Create an application that provides the Navajo Nation with info about water resources to support **increased water accessibility**.

- Identify drivers of **extreme urban heat** and generate of a vulnerability index for urban planning in San Diego, California.
Capacity Building for Community Action

Equity and Environmental Justice

Builds connections with communities to advance equity and environmental justice

✓ Emphasis on co-development and equitable engagement
✓ Combines Earth and social sciences

Health & Air Quality  Energy  Greenspace  Water Resources and Access
Disasters
Food Security

Urban Canopy & Development  Climate and Weather  Wildfires
Want to learn more?

Check out these resources!

- **Environmental Justice Data Backgrounder**
- **Earth Observing Dashboard**
- **UNBOUND for EJ**
TOWARDS INTEGRATED MONITORING FRAMEWORKS

5 Main Areas
17 Goals
169 Targets
231 Indicators

https://sdgs.un.org/goals
https://unstats.un.org/sdgs/indicators/indicators-list/

SUSTAINABLE URBAN DEVELOPMENT TARGETS CLIMATE CHANGE

Strengthening resilience and adaptive capacity to climate-related risks and natural disasters.
Improving human and institutional capacity for climate change mitigation adaptation, early warning and disaster risk reduction.

UN/HABITAT

UNPA

UN WORLD CONFERENCE ON DISASTER RISK REDUCTION 2015 SENDAI JAPAN

CONVENTION ON BIOLOGICAL DIVERSITY
Cities and communities around the world face numerous environmental hazards—e.g., extreme heat events, landslides, pollution, flooding—that they must monitor and address to enhance resilience of their residents to pressing challenges including climate change impacts. Earth observations provide significant cost and time saving in policy areas that are important to delivering successful and sustainable cities.

Example data set: POPGRID-Compare allows users to produce range estimates of population exposure to hazards.

https://eotoolkit.unhabitat.org
Earth observations toolkit for sustainable cities and human settlements

Urban Toolkit - Strengthening Capacity

- Builds on SDG 11 but addresses a wider range of urbanization and human settlements issues.
- Places emphasis on the need to develop capacity of local authorities and other local actors for NUA and SDG implementation at the urban local level.
- Promotes FAIR-ness, contextualization and reusability of EO resources and links to the GEO Knowledge Hub.
- Shares guidance on EO data and tools (national, subnational and city experiences)
- Aims to become a global reference point and “go to” place for city to city and country to country learning.

4 Working Groups

- Hands-on Trainings
- Webinars
- Listening Sessions
- Earth Scientists<>Local Government Pairings

Individual links to download SDG 11 indicator one-pagers can be found here.
The Earth Observations Toolkit for Sustainable Cities and Human Settlements

Enables the use of Earth observations to advance Sustainable Development Goal 11 and the New Urban Agenda
✓ Examples of internationally coordinated initiatives driving progress on UN Sustainability Agreements.

✓ Applications from diverse disciplines: wetland preservation, food security, water quality, marine conservation, disasters, urbanization, drought, land degradation, greenhouse gas monitoring.

✓ Case studies of projects engaging with a broad range of user communities, fostering their skills and capacity & co-designing practical applications to benefit the economy, society and the environment.

✓ Over 30 international contributors

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1. Earth Observation Applications and Global Policy Frameworks: An Introductory Chapter.

   **Part I. Case Studies of Earth Observation Applications for Global Policy Frameworks**


3. A Bird’s View of Monitoring and Management of Marine and Coastal Protected Areas.


5. The Fate of Wetlands: Can the View From Space Help Us to Stop and Reverse Their Global Decline?


   **Part II. GEO Initiatives in Support of Global Policy Frameworks**


10. GEO Global Agricultural Monitoring and Global Policy Frameworks.


Thank you

Argyro.Kavvada@nasa.gov
August 9, 2022

@E04SDG
Environmental Justice @ DEVELOP

- 10-week feasibility studies that apply Earth observations to inform decision making

- Conducted 20+ projects in the past 5 years collaborating with non-profits and local governments

- Identify how Earth observations and socioeconomic data can be combined to better understand the inequities and injustices that some communities face and support informed decision making and action to address them

- **Project themes:** extreme heat & urban heat island effects, urban tree canopy coverage, urban flooding, and landslide risk

DEVELOP EJ Projects in 14 States
Milwaukee Urban Development

Assessing the Drivers of Urban Flood Vulnerability in Milwaukee using the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) Urban Flood Risk Mitigation Model

TEAM: Jack Acomb, Annika Harrington, Lisa Sun, Madeleine Tango

ADVISORS: Dr. Kenton Ross, Lauren Childs-Gleason
STUDY AREA AND PERIOD

Lindsay Heights
City of Milwaukee
Milwaukee County

Milwaukee County, WI

Lindsay Heights
City of Milwaukee
Milwaukee County

January 1
2010

July 22, 2010
5.6 inches / 142 mm

April 9, 2015
3.2 inches / 81 mm

August 2, 2020
4.8 inches / 122 mm

December 31
2020
METHODOLOGY: InVEST MODEL

INPUTS
- Rainfall Depth (IMERG & NWS)
- Land Cover (NLCD)
- Hydrological Soil Type (gNATSGO)
- Area Polygons (Census Block Groups)
- Building Footprints (County LiDAR)
- Damage Loss Table (FEMA HAZUS)

MODEL
- Physical
- Economic

OUTPUTS
- Runoff Retention Percentage
- Nominal Flood Depth
- Potential Damage in Dollars
- Avoided Damage in Dollars
RESULTS: HISTORIC REDLINING

Historically redlined neighborhoods are associated with higher flood depths.

![Graph showing box plots of average nominal flood depth for different HOLC grades: A, B, C, D. The box plots indicate that Grade A has the lowest range and Grade D has the highest range, suggesting higher flood depths.]

![Maps showing flood depth distribution with color-coding for different grades: Grade A (developing), Grade B (developed), Grade C (declining), Grade D (declined).]
Kansas City Disasters

Assessing Environmental and Socioeconomic Factors of Urban Flood Vulnerability in Kansas City, Kansas

TEAM: Hadwynne Gross, M. René Castillo, Eric Sjöstedt, Raychell Velez

ADVISORS: Dr. Kenton Ross, Tyler Pantle (Fellow)
Kansas City experiences exposure of raw sewage and excessive flooding due to **overwhelmed combined sewer systems**.

Neighborhoods affected by disinvestment and historical redlining face higher levels of **social vulnerability**.

Local communities lack access to resources needed to provide financial and temporal insight for urban flood mitigation.

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**Groundwork USA**

Jalisa Gilmore

Lawrence Hoffman

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**Groundwork Northeast Revitalization Group**

Ben Carpenter

Rev. Adrianne Showalter-Matlock
Global Precipitation Measurement
Integrated Multi-satellite Retrievals (GPM IMERG)

INPUTS
- Precipitation Data
- Land Use and Land Cover
- Soil Hydrologic Groups
- Ancillary Datasets

INVEST URBAN FLOOD RISK MITIGATION MODEL
- Surface Runoff (mm)
- Runoff Retention (m³)
- Potential Economic Damage

ENVIRONMENTAL JUSTICE ANALYSIS
- Low Income
- Minority
- No High School Diploma
- Over Age 65
RESULTS

InVEST Outputs

Surface Runoff (mm)

- 0 – 14
- 14 – 29
- 29 – 44
- 44 – 58
- 58 – 73
- 73 – 88
- 88 – 102
- 102 – 117

Runoff Retention (m³)

- 0 – 13
- 13 – 26
- 26 – 39
- 39 – 52
- 52 – 65
- 65 – 79
- 79 – 92
- 92 – 105

Environmental Justice

Minority

Non-White Population

Low

High

Runoff Value

Low Income

Population with Income Below $50,000

Low

High

Runoff Value

Special thanks to Tyler Pantle (Fellow), Celeste Gambino (Senior Fellow), and Dr. Kenton Ross (Science Advisor) for all their help with this project.
Albuquerque Urban Development

Enhancing Urban Cooling Interventions by Modeling Urban Forestry through NASA Earth Observations in Albuquerque, New Mexico

TEAM: Ritisha Ghosh, Robert Stewart, Christina Dennis, Richard Kirschner, Steven Nystrom

ADVISORS: Dr. David Hondula, Dr. Kenton Ross, Ryan Hammock
Impervious, dark surfaces absorb and trap heat

Waste heat from vehicles and machinery

Inter-structure canyons retain heat

Lack of green infrastructure or trees for shade and evapotranspiration

Project Partners:
City of Albuquerque
Dept. of Parks and Recreation
City of Albuquerque
Dept. of Environmental Health
Let's Plant Albuquerque

Image Credit: Created on © Canva, Elements from Sketchify, Alexel, Feaky, Viktor Marozuk, Lenemy Gan, gstudioimagen, and vectorwin
Methodology

ISS: ECOSTRESS
70 meter resolution, temporal revisitation 1-7 days

Landsat 8 TIRS
100 meter resolution, (LST product gridded at 30 meters), temporal revisitation 16 days

InVEST Urban Cooling Model
- Heat Mitigation Index
- Albedo
- Evapotranspiration
- Land Cover
- Shade

ENVI-Met Microclimate Simulation:
Human Thermal Comfort
- Before
- After

UHEAT 2.0 Heat Vulnerability
- Least Priority
- Greatest Priority
Results

Heat Mitigation Index:
With the current green spaces available, how well can different areas in Albuquerque reduce excess heat?

Cooling Capacity:
What happens to the capacity of an area to cool down if we add trees?

Thermal Comfort Index:
How comfortable does the average human feel in this area? How does this change if we add trees?

More Neutral

Hot (Uncomfortable)

Before added trees:

After added trees on the south:
FROM SPACE TO THE STREETS:
USING SATELLITE DATA TO TRACK NEIGHBORHOOD-SCALE AIR INEQUALITY

Gaige Kerr, George Washington University

Special thanks to Susan Anenberg, Daniel Goldberg, Natalie Youssef, Lauren Johnson, Qian Xiao, and Colleen Heck
Recently-launched satellites provide increasingly high resolution NO$_2$ estimates

Nitrogen dioxide (NO$_2$) measured by the TROPospheric Monitoring Instrument (TROPOMI) represents important advancements over predecessor instruments.

SOURCE: GOLDBERG ET AL. (2021) EARTHS FUTURE
Satellite data paired with demographics provide neighborhood-level perspectives on environmental justice

In California’s Central Valley, census tract-averaged NO\textsubscript{2} from TROPOMI was higher in communities of color in 2019.
Racial relative disparities in pollution-attributable health burdens are widening

Successful regulatory measures have reduced the public health damages associated with air pollution, but uneven reductions have resulted in widening disparities.

- Most white = Communities with share of white residents > 90th percentile
- Least white = Communities with share of white residents < 10th percentile
Satellites can track changes in NO$_2$ and associated disparities in near-real time

The COVID-19 pandemic reduced, but did not eliminate, NO$_2$ disparities in the U.S.

In many cities, the least white communities experienced higher NO$_2$ levels during the pandemic than the most white communities faced prior to the pandemic.
“Satellite Data for Environmental Justice:” A NASA-funded scientist-stakeholder partnership

We work with public health and air qualities agencies to assist in the use of NASA data and tools for the public benefits, specifically for environmental justice screening and mapping tools.

All are welcome to attend our monthly team meetings to exchange information and build a community of practice about using satellite data for EJ applications.

When: Every first Wednesday of the month
Time: 11am-12:30pm EST
Where: Zoom

Contact us for more information/how to get involved!
“Satellite Data for Environmental Justice:” Empowering a better understanding of NO₂ exposure

Datasets that incorporate satellite-derived NO₂ can help the general public and decision makers determine which communities may bear larger burdens from NO₂.

SOURCE: EPA EJSCREEN
The pandemic made clear who doesn’t get to breathe clean air. Now what?

By Gaige Kerr and Susan Anenberg Aug. 16, 2021

May 16, 2022

Environmental Protection Agency
EPA Docket Center, OAR, Docket EPA–HQ–OAR–2019–0055
Mail Code 20221T
1200 Pennsylvania Avenue NW
Washington, DC 20460


On March 7, 2022, the EPA released proposed standards to reduce NOx emissions from heavy-duty vehicles (HDVs) and engines. We are researchers focused on understanding the health and environmental impacts of nitrogen dioxide (NOx), fine particulate matter (PM2.5) and ozone pollution, particularly stemming from vehicle tailpipe emissions. We have published dozens of peer-reviewed publications on these topics over the past 15 years. Thank you for considering these evidence-based comments on the proposed standards.

In many urban areas, the most marginalized communities live and work disproportionately close to major highways and interstate.

MARIO TAMAJ/Getty Images

Baltimore

Nitrogen dioxide pollution contributes to more than 1,000 new childhood asthma cases every year in the Baltimore metro region.

% of New Childhood Asthma Cases from Air Pollution

More than 15%

More than 25%

Average across region:

No Data

In higher air pollution areas

SOURCES: STAT NEWS, EPA, ENVIRONMENTAL DEFENSE FUND
Applied Remote Sensing Training (ARSET)

Satellite Remote Sensing for Measuring Urban Heat Islands and Constructing Heat Vulnerability Indices
Urban Heat Islands

- Urban areas experience higher temperatures than outlying areas. This difference in temperature is what constitutes an urban heat island (UHI).
- Difference in temperature has to do with changes in radiative and thermal properties of impervious surfaces i.e., heat-absorbing buildings and pavement.
- Temperatures vary within cities due to the spatial distribution of water, soil, vegetation, and impervious surfaces.
Monitoring Urban Heat Islands – SUHI

• Satellite thermal remote sensing measures SUHI and provides consistent and repeatable observations of the Earth’s surface at various spatial (from local to global) and temporal (diurnal, seasonal, and inter-annual) scales.
Monitoring Urban Heat Islands – SUHI

- Surface Urban Heat Islands (SUHI) represent the difference of land surface temperature (LST) in urban relative to non-urban areas, as well as “hot spots” within urban areas.

\[ \Delta Tu - r = Tu - Tr \]

- where \( \Delta Tu - r \) is UHI intensity, \( Tu \) is urban temperature and \( Tr \) is rural temperature.

- The intensity of the heat island is the simplest quantitative indicator of the thermal modification imposed by urban relative to non-urban areas.
This example shows how to analyze and visualize Landsat surface temperature (ST) time series from Landsat 8 over Washington, DC (USA) from a defined area of interest (aoi).

Parameters:
In: DATE RANGE
YEAR_RANGE
STUDY_BOUNDS
DISPLAY
aoi: delineated rectangle for area of interest

This code is free and open.
By using this code you agree to cite the following reference in any publications derived from them:
NASA Applied Remote Sensing Training (ARSET) program

Computing mean ST across image collection

Histogram of ST_B10
Formerly redlined areas have less **tree cover** today than areas that weren’t redlined.
They have more **paved surfaces**, like roads and parking lots, that absorb and radiate heat.
That adds to up to **higher summer temperatures** compared to the city average.
HVI Construction

- Vulnerability
- Exposure
- Sensitivity
- Adaptive Capacity

Complexity

HVI Construction Method
- Principal Components Analysis
- Weighted Additive Overlay
- Unweighted Additive Overlay
- Simplified HVI

Normalization & Weighting → Aggregation → HVI Score

• Combine CHIRTS-daily WBGTmax record with the Global Human Settlement Layer Urban Centre Data Base

• Create a record of WBGTmax for every urban settlement on the planet from 1983 – 2016 (150 million observations).

• Apply ISO threshold to identify dangerous hot-humid days (e.g., WBGTmax > 30°C) for each city on the planet, from 1983 – 2016 to produce a record of all urban hot-humid heat waves.
THANK YOU!

EARTH SCIENCE APPLICATIONS WEEK 2022

JOIN US TOMORROW 1-4PM EDT

SLIDES & RECORDINGS WILL BE POSTED BY AUG 31st