People Powered Earth Observation: Even Big Data Starts Small

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What is *Citizen-based* Science?

"The contributions of the public to the advancement of scientific and engineering *research and monitoring* in ways that may include:

- Identifying research questions
- -Designing/conducting investigations
- -Collecting and analyzing data
- Developing data applications
- -Developing technologies for science
- -Solving complex problems."











Citizen Science's Value Proposition

Citizen science can help get more science done more efficiently:

- Collect data with improved spatial or temporal resolutions, or increased geographic extent or temporal scale.
- Analyze imagery and Big Data more rapidly and where computer algorithms don't suffice
- Generate new ideas for data applications/technologies
- Theobald *et al* (2014) est. that ~1-2 million volunteers make ~\$2.5 billion in in-kind contributions year to 388 biodiversity research projects globally per year.

Citizen science isn't right for solving every scientific or engineering problem, but it can be valuable when applied to the right scientific or engineering problem and when designed properly.

Examples of Citizen Science in Action

Community Collaborative Rain, Hail, and Snow Network engages more than 35,000 volunteer observers to measure precipitation using standardized rain gauges.





mPING mobile app has collected more than 860,000 ground-based observations that help verify weather models.





Old Weather coordinates crowdsourcing for annotating and transcribing ship log books for temperature, pressure, and weather events. As of Dec 2015, nearly 21,000 volunteers have transcribed over 7.5 million weather observations.





In 2014, Nature's Notebook volunteers recorded more than 1 million observations on plants and animals that scientists use to analyze environmental change.





Crowd Hydrology powered by social water

Chris Lowry, University at Buffalo, and Mike Fienen, USGS WI Water Science Center





In 2014, the National Map Corps made 100,000 edits to structures, such as law enforcement and correctional facilities, to improve topographic maps.



MapGive volunteers mapped 25% of Nimule, South Sudan, including roads, buildings, and bodies of water using satellite imagery and adding to the OpenStreetMap (OSM) database.

OSM Tasking Manager

Help Map for a Safer Padang Task Users Stats Total (1017) Done (793) Validated (25) Done - Validated lumanitarian penStreetMap

You are wondercho

570 GISCorps and Humanitarian OSM volunteers mapped 163,912 buildings and critical infrastructure in Pedang, Indonesia, for disaster resilience, with assistance of Australian Aid and World Bank.



OpenStreetMap.org



In 2012, USAID's Development Credit Authority launched the agency's first crowdsourcing effort. 145 volunteers processed 10,000 records in 16hrs with 85% accuracy.



Advanced Rapid Imaging and Analysis Project engages GISCorps volunteers to help detect and validate surface change in radar imagery. Sponsored by NASA JPL, CalTech, DOE, UCSD, and Agenzia Spaziale Italiana





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SatCam 🛲

SatCam lets you capture observations of sky and ground conditions at the same time that an Earth observation satellite is overhead.

When you capture a SatCam observation and submit it to our server, it helps us to check the quality of the cloud products that we create from the satellite data. In return, we send you the satellite image that was captured at your location, anywhere in the world! SatCam supports the Terra, Aqua, and Suomi NPP satellites.

SatCam was developed at the Space Science and Engineering Center, University of Wisconsin-Madison .





The iSeeChange Tracker is a collaboration with NASA's Orbiting Carbon Observatory Mission. The app allows individuals to follow investigations over time and help NASA ground truth details that Earth Observation satellites can't see from space-including the impacts of weather and climate.



Adopt-A-Pixel engages volunteers to collect ground-based reference data to help Landsat scientists better understand landscape changes.



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Eye on Earth is a window to discovering new ways of seeing the environment. Data is transformed into a powerful visual format which everyone can interact with. What on Earth can you explore? From air quality in your city to water quality at your favourite beach, the maps of Eye on Earth can show you all sorts of things about your environment. Have a look at the featured maps and map applications at the Explore Gallery.





Contribute your environmental observations or geo-spatial content.

By sharing you are helping to fill the gaps in our shared understanding of the environment. The Watches applications let you easily share observations about your environment, such as the quality of air, water, noise, and nature. When seen together with official sources of information, your observations will truly raise public awareness of our environment.

If you are an organisation with content to share or want to make use of the cutting edge geospatial tools offered via Eye on Earth, you will find further instructions from user options.



Create your own new customised maps and share these within closed groups or with everyone.



See how this cutting edge technology can become an effective tool for you. A map can be created in a matter of minutes, as long as you have opened your free account. All you need to do is choose a base map, add whichever content layers you prefer and zoom into your area of interest. Share it within a closed group or make it accessible to the rest of Eye on Earth- the choice is yours. You can also embed the map on your blog or website. These are just a few of the many features you can use when creating your own Eye on Earth map.

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Get involved now!

Participate in these ongoing projects and join the citizen science movement to help us address global land cover issues



Sort pictures and win great prizes! You can help us tackle global issues like deforestation.



Picture Paint Paint pictures and win great prizes! You can help us tackle global issues like deforestation.



Cropland Validation Validate areas of interest as cropland or non-cropland and win great prizes!



FotoQuest Austria Join FotoQuest Austria and explore the outdoors! Help us monitor changes in land use and land cover.



Geo-Wiki pictures Capture different landscapes using your smartphone and share with others through Geo-Wiki.



LACO-Wiki

Discover the new web portal to validate your map products from local to global scales.



ESA-sponsored **CITISENSE CITI-SENSE** will develop, test, demonstrate and validate a community-based environmental monitoring and information system using innovative and novel Earth Observation applications. ESA-sponsored **CROWD4SAT** is a consortium of European research institutes and companies conducting a feasibility study of how crowdsourcing and citizen science can benefit the validation, use and enhancement of satellite products and services.



Case Study 1

Snow covered area in the Pyrenees involving participatory crowdsourcing of snow coverage data from hikers and its integration with Sentinel-1 and MODIS satellite data. Lead: Starlab

Case Studies



Case Study 2

Pollution in large metropolitan areas using satellite data and data opportunistically crowdsourced from tens of thousands of car black boxes, OBD devices, white boxes and telematics insurance mobile apps. Lead: The Floow

Case Study 3

Integration of opportunistically crowdsourced data from social media (Twitter, Facebook, etc.) with satellite data from Sentinel-1, Landsat-8 and MODIS for floods. Lead: e-GEOS



Case Study 4

Land use in the Bacchiglione river catchment area (North East Italy) using photo data from citizens, social media and CORINE land cover data from IRS P6 LISS III and RapidEye. Lead: Starlab



ESA-sponsored SETA creates technologies and methodologies set to change the way mobility is organized, monitored and planned in large metropolitan areas. The solutions are based on large, complex dynamic data from millions of citizens, thousands of connected cars, thousands of city sensors and hundreds of distributed databases.





EU Commission-sponsored WeSenselt Citizen Water Observatories

Enthusiasm growing across the US Government

- Citizenscience.gov: Community of Practice, Toolkit, Catalog
- Agency working groups(NASA, NOAA, USGS, EPA, USFS, NIH, NSF)
- Administration Policies: White House/Holdren memo (Sept 30, 2015); President's Strategy for American Innovation (Oct 2015); US Global Climate Change Program Strategic Plan (Draft Update 2015); US National Plan for Civil Earth Observations (2014); Open Government National Action Plans (2013, 2015).
- Federal Research Funding: FY17 EOP R&D Budget Memo encouraged citizen science; e.g., NSF made citizen science a core funding priority area; NASA ROSES-2016 A.47 Citizen Science for Earth Systems (also ROSES C.21)

US Nat'l Plan for Civil Earth Observations



 Focus on user needs and measurements
 Crowdsourcing and citizen science included for:

- -improving data management;
- -increasing efficiency and cost savings;
- -improving observational density and sampling
- -Expanding availability and use of open data

NASA ROSES-2016 A.47 Citizen Science for Earth Systems

The primary goal of the Citizen Science for Earth Systems Program is to develop and implement capabilities to harness voluntary contributions from members of the general public to advance understanding of the Earth as a system. The program complements NASA's capability of observing the Earth globally from space, air, land, and water by engaging the public in NASA's mission to "drive advances in science, technology, aeronautics, space exploration, economic vitality, and stewardship of the Earth" and <u>Strategic Goal 2.2</u> to "advance knowledge of Earth as a system to meet the challenges of environmental change and to improve life on our planet". The program aims to advance the use of citizen science in scientific research about the Earth by directly supporting citizen science activities, as well as by developing technology to further citizen science research.

Through this solicitation, two types of proposals are sought – citizen science research and low cost sensor deployment for the collection of well calibrated citizen science data.

Tracking a Changing Climate Workshop

Hosted 2014 Public Forum & Workshop at Wilson Center to explore ways in which crowd-based approaches, such as citizen science, and community-based monitoring, are and can be used to support indicators or indicator systems of climate change, impacts, and response.



Physical Climate Indicators

- Precipitation (CoCoRaHS, GLOBE, WeatherBug, Cooperative Observer Program, mPING)
- Drought (UNISDR)
- Flooding (census data, insurance)
- Snow cover (CoCoRaHS, GLOBE, Cooperative Observer Program)
- Air & surface temperature, Humidity (GLOBE, WeatherBug, Cooperative Observer Program)
- Soil Moisture (CoCoRaHS, GLOBE)
- Wind (WeatherBug)
- Water temperature, pH, and Salinity (Multiple regional and local programs)
- Albedo (GLOBE)

Advancing the Science of Citizen Science



Helping federal agencies accelerate innovation through public participation.







Focus on Data Quality

- Quality Assurance Plan
- Repeated sample/tasks
- Participant tasks involving control items
- Uniform or calibrated equipment
- Personal knowledge of participant skills/expertise
- Participant training
- Participant testing
- Rating participant performance
 Data mining
- Filtering of unusual reports

- Contacting participants about unusual reports
- Automatic recognition techniques
- Expert Review
- Paper data sheets submitted in addition to online entry
- Digital vouchers
- Data triangulation
- Data normalization
- - Data quality documentation

Advances in technology are enabling and enhancing citizen science projects

Air Sensor Toolbox for Citizen Scientists provides guidance on affordable, next-generation air quality sensors.





Data Sharing and Infrastructure

A network of four Big Data Regional Innovation Hubs, launched by the NSF in 2015:

- Accelerate partnerships among people in business, academia, and government who apply data science and analytics to advance science, address societal challenges, and spur economic development in the regions.
- Facilitate federated data sharing, computing, and analysis across institutions and partners, leveraging existing efforts such as the NSF-sponsored DataNet Federation, XCEDE, iRODs Consortia, National Data Service, cloud service providers, etc.
- Support NSF-sponsored "spoke" projects, some of which integrate citizen science data with traditional data sources (mHealth, Smart Cities, Smithsonian's Encyclopedia of Life).



Citizen Science & Earth Science

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The Earth Science Challenge

- Earth Science cares about the environment in detail
 - short times and fine spatial resolution
- Satellite remote sensing can't do it all
- Professional *in situ* observations provide essential additions
- Citizen scientists can augment professional observers

Citizen Scientists in Earth Science

Measurement capabilities:

- In situ measurements that cannot be sensed remotely
- Monitoring and maintenance of automated sensing systems
- Collateral contributions:
- Address local problems and applications
- Raise awareness
- Build a base of support
- Improve science education

In Situ Measurements Required

- SMAP scientists need calibration/validation data
- SMAP surface soil moisture measurements need:
 - Extension into coastal areas
 - Information on spatial variations at sub 35 km scales
- Gravimetric soil moisture measurement:
 - Is the Gold Standard
 - Can be made reliably and accurately by citizen scientists
 - Can be done using equipment costing less than \$60
 - Can be done almost anywhere
 - Requires no more than 30 minutes

SMAP and GLOBE

- SMAP discussed needs with GLOBE
 A partnership ensued
- Two members of the science team
 - Developed a revised GLOBE protocol
 - Developed low-cost equipment approaches
 - Serve as GLOBE Scientists for the protocol
 - Communicate with students and teachers
- GLOBE adopted the protocol
 - Adapted its data system ingest, store, share data
 - Supports protocol training & classroom use

GLOBE, SciStarter, YLACES, ECOSchools

- SciStarter proposed to recruit, train, & equip youth groups across the US
- YLACES funded the grant & provides equipment
- SciStarter innovates remote, on-line training
- ECOSchools wants to partner with GLOBE and add science to its sustainability portfolio
- GLOBE, SciStarter, YLACES, ECOSchools combine to recruit, train, & equip ECOSchools
 - Surface soil moisture and temperature, clouds, precipitation
 - YLACES provides up to \$100 of equipment per school

Measurement Sites Todate



Citizen Science Challenges

- Recruiting
 - SciStarter and GLOBE community outreach
- Equipping
 - YLACES funding, NASA grant for lending libraries
- Sustaining interest
 - Feedback, data use, role in education & citizenship
- Getting data where it is most useful
- Information system to ingest, archive, distribute
 - GLOBE Data and Information System

Citizen Earth Science Role in Education

- To learn science, students need to do science
 - Experience the scientific method by doing research
- Environmental citizen science in a resource
 - The lab is conveniently located right outside
 - Equipment costs are low
 - Interesting student research projects are intellectually accessible from an early age
 - Motivation to contribute to real need citizenship
 - Concern for the local, regional, & global environment

Citizen Science in Earth Science's Future

- Technology is enabling
- Increased measurement needs:
 - Types of observations
 - Finer spatial resolution
- Public engagement to use Earth science results
- Unique contribution to 21st Century Science Ed.

What choice do we have?

Some Ideas for Citizen Science and Earth Obs

- Review Earth Science program areas to determine how/where citizen science could advance Earth Observation missions
- Encourage umbrella language in ROSES welcoming proposers to consider citizen science and crowdsourcing methods
- Encourage inclusion of citizen science elements in mission
 Announcements of Opportunity
- Pursue citizen science projects of strategic importance to Earth Science
- Put out calls for tools to aid citizen science projects
- Encourage citizen science in NASA's next Science Plan