

Earth Observation's Promise and Barriers: A Down to Earth View

Published: May 20, 2025 at 11:56 PM Author: Richard Djarbeng 12 min read

In this post I consider the transformative potential of satellite data for tackling global challenges like climate change, food security, and urban planning, while examining the real-world hurdles that limit its impact today. Yet a significant gap exists between what's possible and what's currently being implemented, this article explores both the immense potential and current realities of satellite-based research.

The Untapped Potential

Let us consider the possible use cases of satellite data and also finding some useful examples of how it is being used in a positive way to solve problems on a large scale.



Environmental Monitoring & Climate Science

Satellites provide unique capabilities for monitoring our planet's health at scales impossible to achieve through ground-based methods alone. They enable:

- Real-time tracking of deforestation, wildfires, and land use changes across entire ecosystems
- **Example:** [NASA and the University of Maryland's Global Forest Watch](#) uses Landsat imagery to track forest loss, revealing that an area of tropical forest the size of Switzerland is lost annually
- Precise monitoring of polar ice dynamics and sea level fluctuations down to millimeter accuracy
- **Example:** The [ESA's CryoSat-2](#) has measured Arctic sea ice thickness with unprecedented precision, documenting a 13% decline per decade
- Comprehensive atmospheric composition analysis for better understanding carbon cycles
- **Example:** Japan's [GOSAT](#) and NASA's [OCO-2](#) satellites measure atmospheric CO₂ concentrations at different altitudes, helping validate climate models
- Advanced early warning systems for natural disasters, potentially saving countless lives
- **Example:** NOAA's [GOES satellites](#) provide crucial hurricane formation data up to 72 hours before landfall, dramatically improving evacuation planning

Agriculture & Food Security

The agricultural sector stands to benefit enormously from satellite technologies through:

- Field-level crop health assessments enabling precision farming at scale
- **Example:** [Planet's](#) daily imagery helps farmers detect crop stress from pests or disease up to two weeks earlier than ground observation
- Data-driven yield predictions that can revolutionize crop insurance and market stability
- **Example:** [NASA Harvest program](#) combines satellite data with ground measurements to predict wheat yields in Ukraine within 15% accuracy months before harvest
- Regional soil moisture mapping and drought monitoring to enhance resilience
- **Example:** The [ESA's SMOS satellite](#) measures soil moisture to depths of 5cm, helping predict drought conditions across Africa
- Irrigation efficiency analysis to optimize increasingly scarce water resources
- **Example:** [Stanford researchers](#) use Landsat thermal data to detect irrigation inefficiencies, reducing water usage by up to 20% in California's Central Valley

Urban Planning & Development

Our rapidly urbanizing world needs better planning tools that satellites can provide:

- Detailed 3D city modeling enabling smarter urban design and development
- **Example:** The [German Aerospace Center \(DLR\)](#) used TanDEM-X satellite data to create precise 3D models of over 100 cities, supporting urban heat island studies
- Continuous monitoring of urban heat islands and air quality for healthier cities
- **Example:** NASA's [ECOSTRESS instrument](#) on the ISS maps urban temperatures at 70m resolution, informing cooling strategies in cities like Los Angeles
- Tracking of informal settlements and population movements to improve services
- **Example:** The [World Bank's Global Urban Footprint](#) project uses TerraSAR-X data to map informal settlements in Mumbai, helping target infrastructure improvements
- Infrastructure assessment and planning based on comprehensive spatial data
- **Example:** Researchers use [Sentinel-1 radar interferometry](#) to detect millimeter-scale infrastructure deformation in aging bridges across Europe

Economic & Social Applications

Beyond physical monitoring, satellites enable novel socioeconomic insights through:

- Economic activity indicators derived from night light analysis
- **Example:** [World Bank researchers](#) use VIIRS night light data as a proxy for GDP in regions with limited economic statistics, revealing economic patterns invisible in official data
- Enhanced supply chain visibility and logistics optimization
- **Example:** [Orbital Insight](#) monitors car counts at 250,000+ retail locations using Planet imagery to predict quarterly earnings before official announcements
- Digital inclusion mapping in developing regions
- **Example:** [Meta's Connectivity Initiatives](#) use satellite imagery to identify areas lacking internet infrastructure, helping target their rural connectivity efforts
- Critical monitoring of refugee movements and humanitarian crisis response
- **Example:** [UNHCR partners with UNOSAT](#) to track refugee settlement growth in Bangladesh using Pléiades imagery, enabling more effective aid distribution

Global Health & Disease Surveillance

Health researchers can leverage satellite data to:

- Create risk maps for vector-borne diseases based on environmental conditions

- **Example:** [NASA's DEVELOP program](#) combines MODIS vegetation and temperature data with rainfall measurements to predict malaria outbreaks in Kenya with 70% accuracy
- Monitor air pollution and assess health impacts across populations
- **Example:** [Harvard researchers](#) used Sentinel-5P atmospheric data to document COVID-19 mortality correlations with long-term PM2.5 exposure across 3,000 counties
- Analyze health facility accessibility in remote or underserved regions
- **Example:** [Médecins Sans Frontières](#) uses satellite imagery to optimize mobile clinic locations in conflict zones where ground surveys are impossible
- Track water quality indicators relevant to disease prevention
- **Example:** [University of Wisconsin researchers](#) use Landsat to detect harmful algal blooms in drinking water sources days before they would be detected by conventional methods

The Current Reality

Despite the exciting possibilities of satellite data, its use today faces real-world hurdles that keep it from reaching its full potential. These challenges affect who can use the data, how it's applied, and whether it truly helps solve global problems.



Focus Areas and Funding Imbalances

Satellite data is being used in many areas, but not all get the same attention or resources. Climate change studies, for example, receive a lot of focus because of their global importance, but researchers often work in isolation, studying specific aspects like ice melt or CO₂ levels without connecting their findings to other fields like agriculture or urban planning. This makes it harder to get a complete picture of how our planet is changing. Meanwhile, big companies are pouring money into using satellite data for farming, like helping large farms predict crop yields, but small farmers in poorer regions often get left out because these tools are too expensive or complex. Defense and security projects, like monitoring borders, get huge budgets from governments, but the data is often kept secret, so the public can't benefit. On the other hand, businesses are increasingly using satellites for things like tracking store traffic to predict sales, which is growing fast because it makes money, but it doesn't always address bigger societal needs like disaster preparedness or poverty reduction.

Implementation Challenges

Turning satellite data into practical solutions isn't easy. Most of the technology and expertise are in wealthier countries with big space programs, like the United States or European nations, leaving poorer countries with fewer resources to tap into this data. For example, a small African nation might want to use satellite imagery to predict droughts, but they may lack the computers or trained geospatial analysts to work with it. Even when data is available, making sense of it may require powerful computers, storage systems and complex software, which can be a big hurdle for smaller organizations or communities. Plus, governments and businesses often struggle to turn satellite insights into real-world decisions—like using flood risk maps to plan evacuations—because the information doesn't always reach the right people or isn't presented in a way they can act on. Finally, a lot of funding goes toward building new satellites or fancy tech, but there's less money for projects that directly help people, like teaching farmers in remote areas how to use satellite data to improve their crops.

Sidenote: You may have noticed that the examples above come from organizations in North America, Europe, and Southeast Asia. This reflects the prominence of these regions in satellite data research during my link-gathering process, not a lack of global efforts. I plan to hopefully follow up with a post showcasing existing use cases for satellite data in underrepresented regions such as Africa to address this gap.

Systemic Limitations

There are bigger, structural issues that make satellite data less accessible to everyone. First, the best data and tools are often controlled by rich organizations or countries, creating a gap where only those with money or expertise can use high-quality satellite images. Poorer regions, which might need this data the most to deal with issues like floods or food shortages, often can't afford it or don't have the skills to use it. Checking satellite data against real-world conditions such as verifying a forest loss map by visiting the area, is also tough in remote places, making it harder to trust the results. Lastly, the people who understand satellites (like engineers) and those who understand local problems (like farmers or city planners) don't always work together, so the data doesn't always solve the right problems. This disconnect keeps satellite data from making the impact it could.

Satellite Data Platforms and Providers

The satellite data ecosystem includes a mix of government, commercial, and open-source platforms:

Government Platforms

- **[NASA Earth Data](#)**: Provides free access to vast archives of Earth observation data, including from Landsat and MODIS satellites
- **[European Space Agency's Copernicus Data Space Ecosystem](#)**: Offers free, full, and open access to Sentinel satellite data
- **[NOAA's GOES Image Viewer](#)**: Provides real-time geostationary satellite imagery primarily for weather monitoring
- **[JAXA's G-Portal](#)**: Japan's platform for accessing data from ALOS and other Japanese Earth observation satellites

Commercial Providers

- **[Planet](#)**: Operates the largest constellation of Earth-imaging satellites, offering daily imagery at 3-5m resolution on a subscription basis
- **[Maxar Technologies](#)**: Provides very high-resolution imagery (30cm) through their WorldView constellation, primarily serving government and enterprise clients
- **[Airbus Defence and Space](#)**: Offers optical and radar data from their Pléiades and TerraSAR-X satellites at premium pricing

- **ICEYE**: Specializes in SAR (Synthetic Aperture Radar) data that can see through clouds and darkness, with usage-based pricing

Open-Source and Hybrid Initiatives

- **Google Earth Engine**: A powerful cloud-based platform that combines free public datasets with scalable computing infrastructure, allowing users to analyze petabytes of satellite imagery for environmental and development applications. Earth Engine hosts datasets like Landsat, Sentinel, MODIS, and climate models, making them accessible through JavaScript and Python APIs. While free for research, education, and nonprofit use, commercial applications require paid licenses. If interested in Google Earth Engine specifically I have a post focused on that-
[Google Earth Engine: A Useful Tool for Satellite Imagery](#).
- **Microsoft's Planetary Computer**: Provides access to petabytes of environmental data with computational resources and AI tools for analysis, focusing especially on biodiversity and conservation applications
- **Radiant Earth Foundation**: Creates open-source tools and training data specifically for sustainability applications in developing nations
- **Open Data Cube**: An open-source framework for accessing and analyzing satellite data used by several national programs including Digital Earth Australia and Africa Regional Data Cube

Data Access Reality

Despite increasing availability, significant barriers remain:

- Commercial high-resolution imagery can cost thousands of dollars per image
- Free government data often has lower resolution or less frequent coverage
- Processing raw satellite data could require specialized expertise and computing resources
- Licensing restrictions can limit how data can be used, particularly for commercial applications

This fragmented landscape creates a digital divide where advanced capabilities remain concentrated in wealthy institutions and countries that can afford premium data access and processing capabilities.

The Path Forward

This exploration of satellite data's potential and challenges reveals its transformative power across diverse fields, from tracking deforestation and predicting crop yields to mapping urban growth and monitoring global health. You have seen how satellites enable many use cases across diverse fields, with examples like NASA's Landsat, ESA's Sentinel, and commercial platforms like Planet driving innovation. Yet, the journey from potential to impact is hindered by significant barriers: data access inequities, technical complexities, funding imbalances, and disciplinary silos. These challenges, concentrated in wealthier nations and institutions, limit the reach of satellite data, particularly in underserved regions. Bridging this gap demands not only technological advancements but also global collaboration, capacity building, and decision-support systems to make these insights actionable, ensuring satellite data fulfills its promise to address pressing global challenges.

Disclaimer: Some of the images in this post are AI generated by grok(xAI).