ICWP
INTERSTATE COUNCIL ON WATER POLICY

FEDERAL REMOTE SENSING PROGRAMS

Chase Lincoln June 2024

Introduction

The purpose of this brief is to document some of the existing federal remote sensing programs and their utility related to changing conditions in regional and state water resource management and how members of the Interstate Council on Water Policy (ICWP) may use or support the technology in the future.

Understanding how federal agencies are conducting and funding their remote sensing programs can be beneficial to ICWP's mission of developing solutions to water resource challenges.

This brief could not address every technology and policy issue, given limited time, scope and experience, however, it provides several recommendations that ICWP members may consider and perhaps expand upon with their broader perspectives and experiences. The Interstate Council on Water Policy is a nonprofit with a mission to enhance the stewardship of the nation's water resources by serving as the national policy voice for state and interstate water resource managers.

This project was conducted by Chase Lincoln, a recent Political Science graduate of Howard University and a Spring 2024 Water Policy Intern for ICWP. He spent the semester researching remote sensing programs at federal agencies, with a focus on NASA and USGS.

Background

Remote sensing is the use of various technologies to collect data about an object from a distance.

Some examples of remote sensing technologies include radar, lidar, and satellites.

There are two types of satellite sensors. **Active sensors** use their own energy source while **passive sensors** draw energy from the Sun to function. Passive sensors function by using different types of radiometers (instruments that quantitatively measure the intensity of electromagnetic radiation in select bands) and spectrometers (devices that are designed to detect, measure, and analyze the spectral content of reflected electromagnetic radiation).[1]

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[1] N.d., *What is Remote Sensing* (NASA Earthdata).

Most passive sensors used by remote sensing applications operate in the visible, infrared, thermal infrared, and microwave portions of the electromagnetic spectrum. These sensors can measure and detect the surface temperatures of both bodies of water and land masses, as well as vegetation, cloud, and aerosol properties. Most passive sensors cannot penetrate dense cloud cover and thus have limitations observing areas like the tropics where dense cloud cover is frequent.[2]

Active sensors include different types of radio detection and ranging (radar) sensors, altimeters, and scatterometers. Most active sensors operate in the microwave band of the electromagnetic spectrum, which allows them to detect objects on the Earth's surface, through the atmosphere. These two types of sensors are useful for measuring the vertical profiles of aerosols, forest structure, precipitation and winds, sea surface topography, and ice, among others.[3]

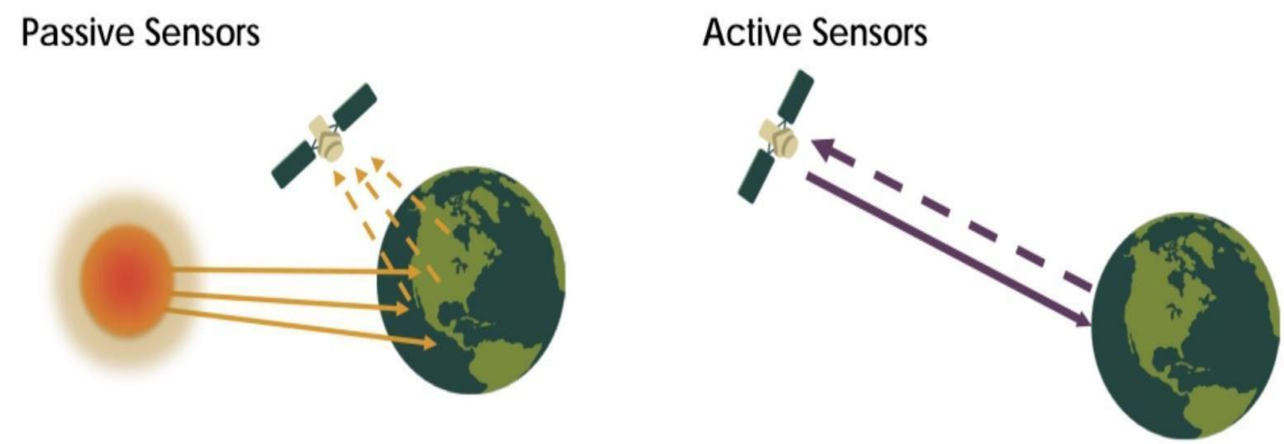

Diagram of a passive sensor versus an active sensor. Credit: NASA Applied Sciences Remote Sensing Training Program.

Interviews

To better understand these programs, interviews were conducted with several members of leading federal agencies with expertise in remote sensing related fields. These interviews took place both in-person at the 2024 Washington DC

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[2] N.d., (NASA Earthdata).
[3] N.d., (NASA Earthdata).

Roundtable on March 13, 2024, as well as virtually over Zoom and Microsoft Teams in the weeks after. These interviews were approximately 25 to 45 minutes and focused on addressing open-ended questions that were most relevant to the research purpose of this project.

Some of the questions asked included:

1. **What is the current state of remote sensing technology employed by your agency/department relative to water resources?**
2. **What types of technology are being used the most by your agency/department?**
3. **How has technology advanced in recent years, and what new capabilities does remote sensing offer for water resources management?**
4. **What plans or initiatives are in place to improve resolution and precision of monitoring?**
5. **What is the resolution (spatial and/or temporal) of the remote sensing data currently used for monitoring water resources?**
6. **What are the challenges or gaps in integrating remote sensing with on-the-ground measurements?**
7. **To what extent does your agency/department use remote sensing data along with ground-based monitoring systems?**
8. **What, if any, is the role of machine learning and artificial intelligence in this area?**
9. **How can remote sensing data address climate resilience and impacts within water resource management?**
10. **What strategies does your agency/department use to share data and coordinate with states/interstates? Other federal agencies?**
11. **Is this data being shared via open access or only via partnerships, agreements and the like?**
12. **What's one piece of advice you would give to a state or interstate agency looking to leverage remote sensing data in their water resources management?**
13. **What budgeting is currently in place for remote sensing initiatives related to water resources at your agency/department?**
14. **Are there funding gaps, and how can Congress best address them?**
15. **What is a success story you can share about your agency/department's work on this topic? From the West Coast, East Coast and/or Midwest?**

Analysis

The interview responses varied widely and not all interviews covered each question. The remainder of the semester was spent summarizing and identifying themes and recommendations from these robust conversations. The following topics emerged as top areas of focus and issues to consider.

Remote Sensing Technology

Many of the interviewees spoke about the specific technology in current use or in development at each of their respective agencies.

Some of the more notable satellites or sensors that were brought up were the **PACE** mission, the **NISAR** mission, and the **MODIS** sensor.

Kevin Ward of the National Aeronautics and Space Administration (NASA) mentioned PACE as a new technology that could benefit bodies of water that are connected to the ocean, such as estuaries on the eastern coast of the United States. PACE is a new NASA mission, launched in 2024, specializing in ocean health assessment. It is also equipped with an OCI (Ocean Coloring Instrument) sensor, useful for detecting different types of organic matter such as algal blooms, cyanobacteria, phytoplankton, and chlorophyll concentrations.

Both Kevin Ward and Stephanie Granger, also from NASA, discussed the importance of NISAR's viability in changing climatic conditions. NISAR is a synthetic aperture radar that can provide highly detailed images of the Earth's surface to assist in disaster mitigation by measuring groundwater volumes, biomass, sea level changes, ice mass, and glacial depth.

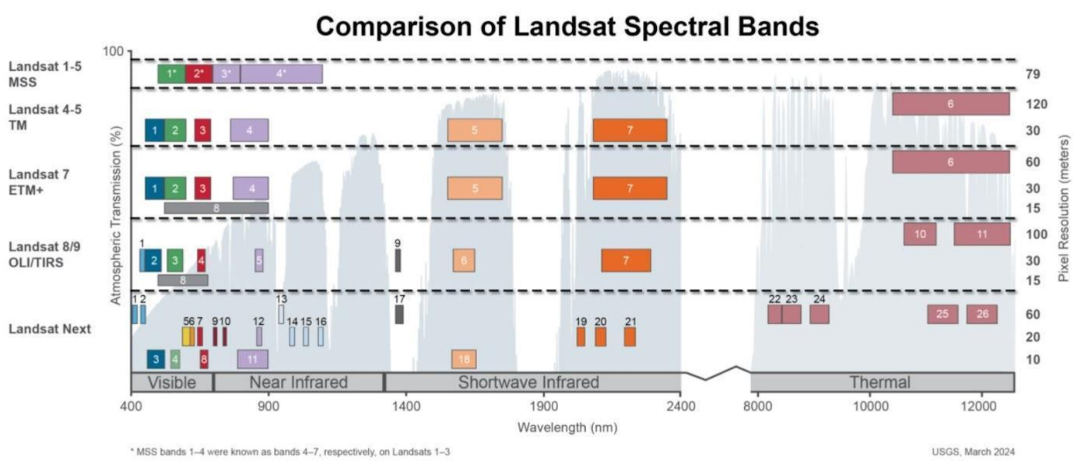
MODIS is a remote sensor used by two NASA satellites, Terra and Aqua. MODIS is used by the Terra satellite to measure water vapor and cloud coverage in the atmosphere and changes on the Earth's surface. It can observe phytoplankton blooms and photosynthetic activity and can collect data on climate related patterns such as carbon dioxide levels, El Niño/La Niña events, and sea surface temperature changes.

Some of the interviewees do not work in the water resources divisions of their agencies, but the overlap in how these programs are being used to manage land and water resources made their insight on remote sensing relevant. For example, Tim

Newman and Tim Stryker, both representatives of U.S. Geological Survey USGS, were interviewed together at ICWP's Washington DC Roundtable. While they both work in land imaging divisions of USGS, they discussed the Landsat program and answered questions about the way that this technology, specifically the **Landsat Next** program set to launch in 2030, can benefit water resource management.

The **Landsat program** was mentioned by nearly every interviewee, especially those that worked at either **NASA** or **USGS**. Landsat consists of a series of Earth-observing satellite missions jointly managed by **NASA** and **USGS**. NASA is a **research and development agency** that produces satellites and remote sensors which are operated by USGS, an **operational agency**. The program was first proposed in 1965 by William T. Pecora, the director of the USGS, at the time. Its first launch began on July 23, 1972, with Landsat 1. To date, there have been nine missions, eight of which have been operational. Landsat Next will be the program's tenth mission, launching three satellites in lower orbit, with an estimated cost of $506.7M[4], that will provide more thermal imaging directed towards water resource management. It will also include improved spatial resolution with increased detection of the dynamic imaging of water surfaces such as lake and snow extents.

Below is a graph comparing the development of specifications throughout the Landsat program's lifespan.



Sources/Usage: Public Domain. View Media Details

This image shows the spectral bandpasses for the sensors on all Landsat satellites. *Landsat MSS = the numbers shown are for Landsat 4 and Landsat 5; Landsat 1-3 band numbers are 4, 5, 6 and 7.

[4] N.d., *Landsat Next Instrument Contractor Selected* (U.S. Geological Survey).

Funding

Landsat, like other remote sensing programs at federal agencies, is funded by Congress. For the first two decades, funding was inconsistent, until the passage of the **Land Remote Sensing Policy Act (Public Law 102-555)**, in October 1992. This Act secured the continuation of the Landsat program for years to come. It also demonstrated an investment by the federal government in supporting remote sensing programs. However, the proportion of funding for remote sensing programs at federal agencies, relative to their overall spending budgets, remains low. Jack Eggleston, a representative of the USGS, said that about one third to 40% of funding for the USGS is directed towards the Water Mission Area. Yet, only about 2% of funding is secured for remote sensing. While this amount is growing, it is important for program managers or Congress to direct more funding specifically towards the programs.

The Landsat program also faced a budget reduction in the most recent federal budget. The FY 2024 enacted budget decreased appropriations for the USGS's National Land Imaging Program, which operates Landsat satellites, by $11.4 million from the FY2023 level. Given the costs of managing existing satellites and continuing to advance Landsat Next, funding will remain a key indication of support.

Data

Data collected from remote sensing programs at agencies such as NASA, USGS, and NOAA are open access, made available to the public through each of their respective online viewing platforms. Each of the interviewees stressed the importance of open access data for images captured by remote sensing programs. Due to the massive volumes of data being collected for distribution, and because of its open access policy, according to Timothy Stryker, Landsat data is now being moved to and stored on an Amazon Web Services (AWS) cloud-based server.

Timothy Newman and Timothy Stryker spoke to the history of data access within the Landsat program. Previously, images collected by remote sensing satellites had been for commercial use only. For the first few decades of the Landsat program, data collected by satellites was sold on demand. The passage of the **Land Remote Sensing Commercialization Act** in 1984 increased the pricing of images, which led to a decrease in demand. Images used by NASA's Earth Observatory Group had to be requested from a specific satellite or sensor to be processed. Only after an image was developed, could it be determined whether it was viable.

Data from Landsat satellites was made open access and free to the public in January 2008, with the signing of the **Landsat Data Distribution Policy**. Making data free to the public caused a rapid increase in the number of downloaded images. Before 2008, approximately 25,000 images were being purchased a year. After the signing of the Landsat Data Distribution Policy, this increased to 20,000,000 images.

Some of these viewing platforms are independent to each federal agency, while others are collaborative projects across agencies. For example, **OpenET** is an online platform funded in part both by NASA and USGS and provides open access satellite-based evapotranspiration (ET) data collected from federal remote sensing programs, including Landsat.

Each of the representatives interviewed stressed the importance of keeping data collected open access, as funded dollars support these programs.

Machine Learning and AI

When asked about the role that machine learning plays in tracking and verifying data collected from remote sensing programs, there seemed to be a consensus by all of those interviewed. They agreed that while machine learning algorithms are helpful in conducting real time data analysis of large data sets and detecting data anomalies, human scientists and researchers will always be fundamental in the validation of data. Additionally, while the role of AI is not being widely used at most federal agencies, there is a potential for its development within the coming years.

Challenges

Federal remote sensing programs face several challenges, some of which are specific to their agency and its goals, while others, such as funding, are universal.

One common issue includes the limits to what satellites can detect from a distance. In situ (on the ground-based) technology can continuously collect data over a limited geographical range, whereas remote sensors may only pass over a specific global point every few days but can collect data over large regions of the planet. One of the challenges is the integration of both in situ and remote sensing data.

Another issue is attempts to commercialize some of these federal programs such as Landsat. While many remote sensing programs are run by the federal government, it is important to continue support for and the expansion of funding to secure their continuation.

Application

Remote sensing programs can help with water resource management in several ways. While some of the problems facing water resource management are based on individual state or regional-based needs, many of them overlap. Some common issues include salinity intrusion into estuaries, changes in reservoir water supply levels, harmful algal blooms, changes in precipitation, coastal and terrestrial flooding, and other natural disasters.[5]

Amy Shallcross, manager of Water Resource Operations at the Delaware River Basin Commission described some of the issues facing the basin and how remote sensing could be used to address them. Flooding, harmful algal blooms, reservoir spill mitigation, and tree canopy coverage, among others, can all be tracked through remote sensing. For example, LIDAR data can be used to determine the extent of watersheds. Remote sensors such as MODIS, Landsat, NISAR can provide estimates in snow cover areas at higher elevations.

Ellen Ramirez, a Supervisory Physical Scientist and Deputy Chief of the Mission Operation Division (MOD) at NOAA, added that remote sensing is essential in mapping large bodies of water where there are data voids that in-situ technology cannot measure.

Stephanie Granger, the Program Director for NASA's Western Water Applications Office (WWAO), explained how data being collected from NASA satellites is being used in collaboration with local, state and federal water authorities to help advance water management solutions in the western United States. The WWAO provides needs assessments for these drainage basins and identifies areas where NASA's remote sensing data can add value. Once a needs assessment is conducted, then a request for data is submitted to aid in project funding.

Recently, the WWAO completed five projects in the Columbia River Basin that used Landsat and MODIS data. One of these projects, with the U.S. Forest Service

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[5] N.d., *About – OpenET* (OpenET).

in collaboration with the University of Idaho and the Portland State Water Bureau, incorporated Landsat data using the OpenET viewer to show impacts of fire damage in a Portland-area watershed (pre-fire and post-fire images) to help assess vegetation recovery and erosion potential. Another project with the Natural Resources Conservation Service used MODIS snow data for streamflow prediction in four different basins across the U.S.

Landsat data has, and is currently being used, to assist in natural disaster management. By providing visual imaging from Landsat satellites in areas that would otherwise be difficult to access, this data can be beneficial in assisting federal agencies, such as FEMA, with disaster response and management to mitigate damage caused by natural disasters flooding.

Landsat 8 and 9 satellites captured these before and after images of Northern California showing turbid rivers, rising reservoirs, and saturated fields after record rainfall in Fall of 2022.

Before

After

Recommendations

ICWP members may have varying degrees of experience and awareness of federal remote sensing programs, but in most cases, have robust in situ data and information from years of on-the-ground monitoring and coordination. Working more closely with federal agency partners on remote sensing policy can strengthen programs within both federal and state/interstate agencies.

One key takeaway from the interviews is that ICWP has an opportunity to develop a robust legislative strategy to approach Congress on funding for remote sensing. With so many water resources applications for remote sensing technology, particularly with the Landsat program, ICWP could be a leading voice to maintain and grow support for these programs.

Another opportunity for ICWP highlighted by the interviews is to coordinate regular touchpoints with USGS, NOAA and NASA and others, outside of the roundtable, to grow understanding of and align on challenges and opportunities within the remote sensing area.

ICWP can also benefit from the network of professionals that work in remote sensing at federal agencies. Many of the interviewees were familiar with each other and, although some had nuanced views specific to the area that they work in, many of them shared similar specifics on how remote sensing can be used to promote strategic water resource management.

To build wider support for remote sensing programs and to better integrate local data, ICWP also could consider developing success stories and/or case studies of members using federal remote sensing data. This in turn could bolster funding support by connecting broad federal programs with localized stories and needs that may enable congressional appropriators to better understand local use cases.

Finally, by convening members and agency partners, ICWP has an opportunity to tap into its members' regional and local in situ data to better coordinate and advance data validation and hear from government end users represented in the Council. A ready structure for this may be a subcommittee of ICWP's existing water data committee.

Acknowledgements

Thank you to the many experts that provided their insights through interviews or informal conversations. They include:

1. **Stephen Aichele**
   Geographer, USGS National Geospatial Program
2. **Jack Eggleston**
   Chief, Hydrologic Remote Sensing Branch
   USGS Water Resources Mission Area
3. **Stephanie Granger**
   Program Director, NASA Western Water Applications Office
   Technical Group Supervisor, Applied Science Systems Engineering
   Instrument Software and Science Data Systems - Section 398
   Jet Propulsion Laboratory
   California Institute of Technology
4. **Timothy R. Newman**
   Program Coordinator, USGS National Land Imaging Program
   Acting Program Coordinator, USGS Land Change Science Program
5. **Ellen Ramirez** –
   Deputy Chief, NESDIS/OSPO | Mission Operations Division
   NOAA Satellite Operations Facility (NSOF)
6. **Amy L. Shallcross, P.E.**
   Manager, Water Resource Operations
   Delaware River Basin Commission
7. **Timothy S. Stryker**
   Chief, Outreach and Collaboration Branch
   USGS Office of Land Remote Sensing
8. **Kevin Ward**
   NASA Earth Science Division Digital Strategy Lead
   NASA Earth Observatory Group

Thank you to Beth Callaway, ICWP's Executive Director, and to internship co-advisors Beth Brown and Chris McCann at the Delaware River Basin Commission for providing feedback and guidance.

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