

Landsat Satellites 4-9

Water resources management

Introduction

The stewardship of water resources is vital because the U.N. Environmental Program estimates that 1.8 billion people will face water scarcity by 2025. Water is essential for survival, supporting drinking, farming, energy, industry, and ecosystems. Managing this resource is urgent due to stress from climate change, population growth, and rising demand, underscoring the necessity that good decisions require good data. The Landsat Solution Earth observation, specifically the Landsat 4-9 satellite missions (jointly operated by NASA and the U.S. Geological Survey (USGS)), provides the required data through decades of consistent, high-resolution imagery. These satellites play a vital role in water resource management by:

- tracking changes in **freshwater availability**
- monitoring **droughts**
- mapping **irrigated agriculture**
- observing **snowpack and glaciers**
- assessing the **health of aquatic ecosystems**

By delivering accurate, long-term data, Landsat helps decision-makers make informed decisions to ensure a sustainable future.

Landsat for water monitoring

Landsat satellite data is essential for effective water resource management, providing consistent, long-term observations of surface water bodies and land use changes. Its multispectral sensors, particularly in the blue and red bands, enable monitoring of water clarity, detection of algal blooms, and assessment of ecosystem health.

Landsat also helps identify nutrient pollution by detecting eutrophication symptoms linked to fertilizer use and land management practices. [\[src\]](#)

Additionally, the integration of thermal infrared and optical data allows for the estimation of evapotranspiration [\[src\]](#), supporting field-scale quantification of agricultural water use, irrigation efficiency, and drought response.

Furthermore, Landsat's openly accessible and non-proprietary data ensures equitable access for researchers, resource managers, and policymakers globally, making it a foundational tool for sustainable and data-driven water management.

Landsat Sensors

Landsat 4 & 5

- Multispectral Scanner System (MSS)
 - Four bands, with resolution of 57m x 79m
- Thematic Mapper (TM)
 - Seven bands
 - Six bands with spatial resolution of 30m
 - One band for thermal infrared with resolution of 120m

Landsat 6

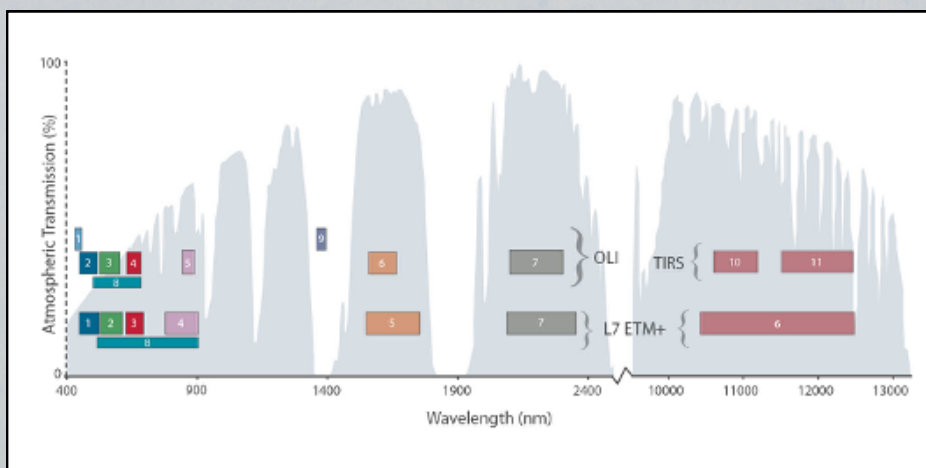
- Failed to achieve orbit
- Enhanced Thematic Mapper (ETM)
 - Same first seven bands as Landsat 4 and 5, with same resolution
 - Eight band with spatial resolution of 15m, sensitive from green to near infrared

Landsat 8

- Operational Land Imager (OLI)
 - Resolution of 30m (visible, NIR, SWIR)
 - Resolution of 15m (panchromatic)
- Thermal Infrared Sensor (TIRS)
 - Resolution of 100m (thermal)
- Two new spectral bands
 - Made for detecting cirrus clouds
 - Made for detecting coastal zone observation
- 11 bands in total

Landsat 7

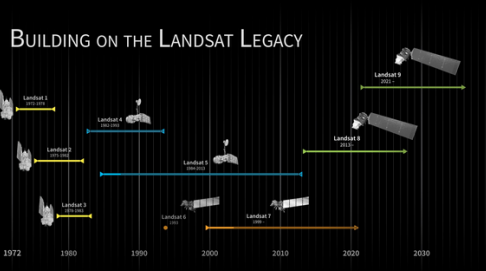
- Same instrument as 4 & 5
- Enhanced Thematic Mapper Plus (ETM+)
 - Panchromatic band with spatial resolution of 15m
 - Full aperture 5% absolute radiometric calibration
 - Thermal IR channel with spatial resolution of 60m



Spatial graph: Landsat 7 ETM+ vs Landsat 8 OLI and TIRS
Image credit: NASA Landsat 8 webpage

Landsat 9

- Replaces Landsat 7
- Landsat 8 + Landsat 9 revisit time for data collection is 8 days
- Image per day : 700+
- Operational Land Imager 2 (OLI-2)
 - Same as OLI but with improvement on problems experienced on Landsat 8
- Thermal Infrared Sensor 2 (TRIS-2)
 - Same as TRIS

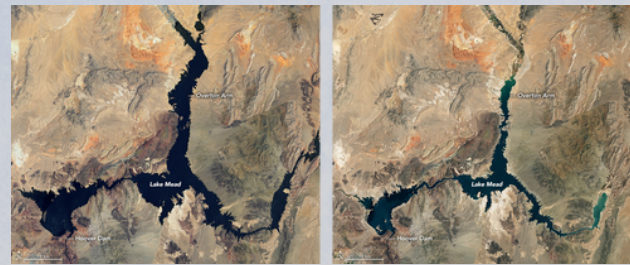


Timeline of the Landsat program, starting with the launch of Landsat 1. Landsat 9, launched September 27, 2021, will continue the legacy of the Landsat program.
Image & description credit: NASA Landsat 9 webpage

Sources : NASA Landsat Science

Mapping reservoirs for better water management

Accurate, frequent monitoring of reservoir water levels is crucial for water resource management, flood control, and hydropower generation, but *in situ* data is often limited. The SARAH-CONUS (Sub-weekly Area of Reservoirs from Analysis of HLS for the Continental U.S.) algorithm addresses this by utilizing Harmonized Landsat and Sentinel-2 (HLS) data. HLS integrates observations from Landsat 8 and 9 with Sentinel-2, significantly improving temporal resolution to an average global revisit of 1.6 days, overcoming the limitations of individual satellite systems. SARAH-CONUS employs a machine-learning model to classify water, non-water, cloud, and ice pixels across over 1,900 reservoirs, generating detailed time series of surface water extent. This enables water managers to make more informed decisions on water allocation, provides early drought warnings, and supports agricultural irrigation planning. [\[src\]](#)



Dramatic decline in Lake Mead's water levels. Left: Landsat 7 captured on July 6, 2000. Right: Landsat 8 captured on July 3, 2022. This illustrates satellite-based change detection for reservoir management. Credit: NASA's Earth Observatory/Lauren Dauphin.

Satellite detection of harmful algal blooms

Harmful algal blooms (HABs) threaten public health, recreational activities, and aquatic ecosystems in lakes and reservoirs. Landsat 8 (and Landsat 9) satellites provide crucial data for monitoring and detecting these blooms. Landsat 8's high spatial resolution allows scientists to identify even small problem areas within larger lakes by detecting increased levels of chlorophyll-a, a green pigment indicative of algal growth. This capability enables water resource managers to receive early warnings, allowing them to conduct targeted *in situ* testing and take necessary actions to ensure water safety for people and pets. For instance, Landsat satellite-based detection of a 2017 bloom in Utah Lake saved an estimated \$370,000 in healthcare and related costs. Algorithms are being automated to make these sophisticated analyses readily available, improving decision-making for water quality management globally. [\[src\]](#)



Data from the Landsat 8 satellite can help resource managers identify potentially harmful algal blooms in water bodies like Utah Lake, seen here. Image credit: NASA/USGS Landsat

Conclusion

Water scarcity is a global crisis, making effective water resource management vital for human survival and ecosystem health. Landsat satellites provide decades of consistent, high-resolution, and openly accessible data that are essential for monitoring and managing water resources.

From detecting harmful algal blooms and nutrient pollution to mapping reservoirs and estimating agricultural water use, Landsat enables informed, data-driven decisions for sustainable management. The integration of optical and thermal data also allows estimation of evapotranspiration (ET), supporting accurate tracking of irrigation and water use.

This information empowers decision-makers with insights for drought response, irrigation efficiency, and water quality management.

