

Long-Term Monitoring with Landsat 4-9

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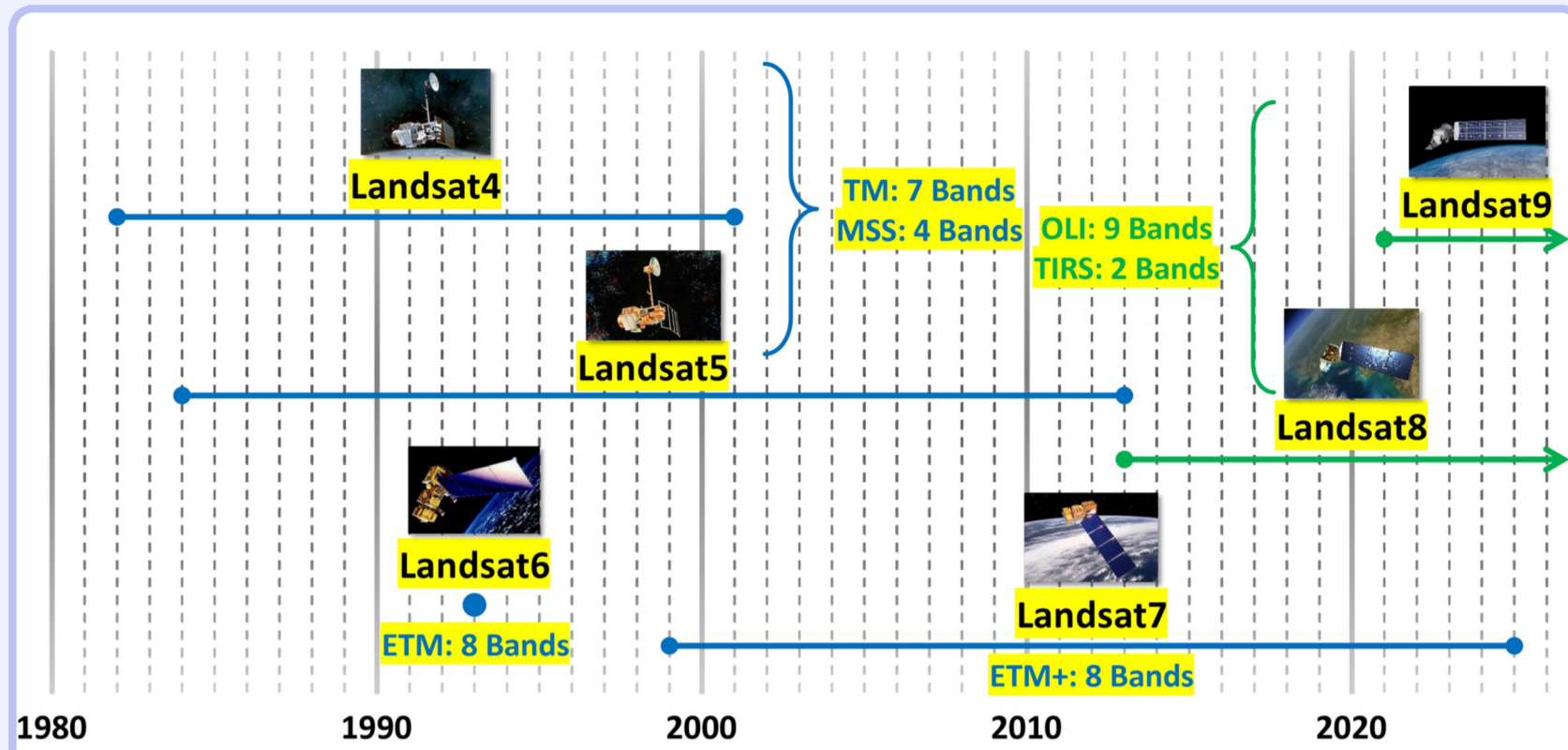


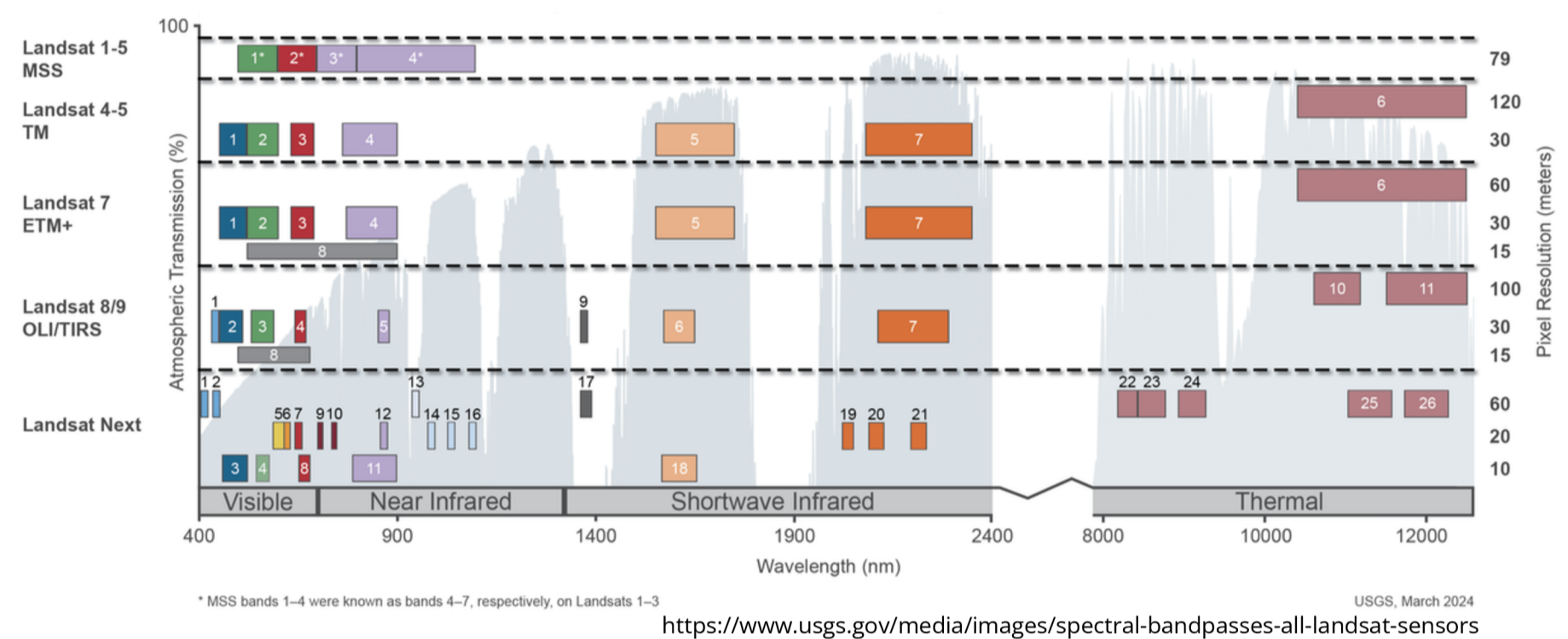
Figure 1: Life span, instrument composition and number of spectral bands of Landsat 4-9 (blue line: decommissioned / green line: operational).

The **Landsat** program, jointly managed by NASA and the U.S. Geological Survey (USGS), has launched 9 satellites since 1972, providing the longest continuous and consistent Earth observations.

For Landsat 4-9, while the 30-meter spatial resolution in the optical bands has been a consistent strength, key enhancements include the refined 15-meter panchromatic band since Landsat 7 and the advanced dual-band thermal instrument on Landsat 8-9, significantly improving image sharpness and temperature measurement accuracy.

Each Landsat satellite has a **16-day revisit** cycle, which is effectively reduced to **8 days** through the combined operation of Landsat 8 and Landsat 9 in complementary orbits.

Landsat Spectral Bands & Resolution



USGS, March 2024
<https://www.usgs.gov/media/images/spectral-bandpasses-all-landsat-sensors>

Long-Term Monitoring

What it is

- Continuous observation of **Earth's surface** and **environment** over years to decades.
- Focuses on detecting **gradual changes** and **long-term trends**, rather than short-term events.

Goals

- Build **consistent data records** for climate and environmental studies.
- Track global change processes: **deforestation, urbanization, glacier retreat, desertification, biodiversity loss.**
- Support **policy** and **management decisions** (e.g., sustainable land use, climate adaptation).

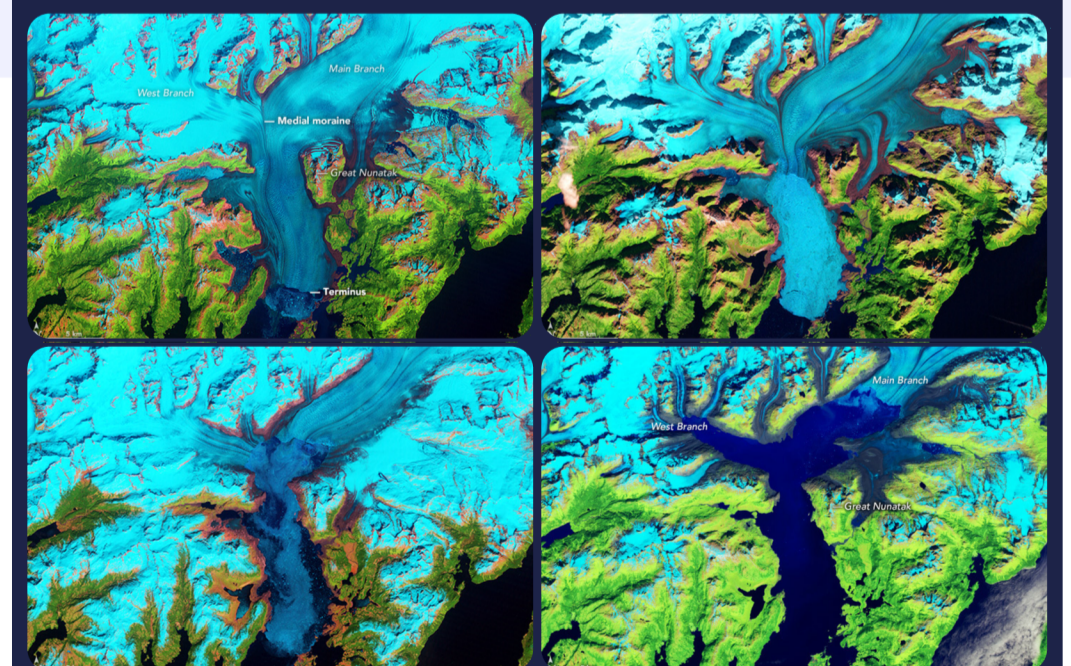
Challenges

- Temporal consistency:** Ensuring comparable data across decades despite technology changes or observation conditions.
- Data continuity:** Maintaining uninterrupted records despite sensor failures or program gaps.

- Data volume:** Handling and processing massive archives of multi-decadal Earth observations.
- Uncertainty sources:** Cloud cover, atmospheric effects, and variability in data acquisition.
- Integration:** Combining multi-sensor, multi-source datasets into coherent long-term series.

Why Landsat 4-9 Works?

- Provides an **uninterrupted multi-decadal record**, unique among Earth observation missions.
- Ensures **data consistency and comparability** across generations of sensors.
- Offers a **global, standardized, and openly accessible archive** supporting reproducible research.
- Combines **improved spatial resolution** and **shorter revisit times** with **expanded spectral coverage**, strengthening the ability to track gradual environmental change.



Columbia Glacier changes over time (1986, 1999, 2011, 2024) captured by **Landsat satellites (4, 5, 7, and 8)**.

<https://earthobservatory.nasa.gov/world-of-change/ColumbiaGlacier>

Research

- Hansen et al. (2013, Science)** – *High-Resolution Global Maps of 21st-Century Forest Cover Change*: Map global forest cover change (2000-2012) with Landsat archive
- Gök et al. (2024)** – *Land surface temperature trends derived from Landsat imagery in the Swiss Alps*: Extract multi-decadal land surface temperature (LST) trends using Landsat 5-8 time series
- Demarquet et al. (2024)** – *Continuous change detection outperforms traditional post-classification change detection for long-term monitoring of wetlands*: Monitor long-term wetland changes in France using the Landsat archive (1984-2022)

Industry

- Google Earth Engine (GEE)**: Hosts full Landsat archive for large-scale time-series analysis and public tools (e.g., Timelapse)
- ABOVE**: Dataset of Landsat vegetation greenness trends from 1985 to 2019 in the boreal forest biome

Applications

References

- Landsat Science: <https://landsat.gsfc.nasa.gov/>
- Google Earth Engine: <https://earthengine.google.com/>
- USGS: <https://www.usgs.gov/>
- EARTHDATA: <https://www.earthdata.nasa.gov/>