

## Slide 1 – Title Slide

Hello and welcome to Week 10, part 5 of EGM310: Satellite data and where to find it. In this lesson, we'll learn about different Earth observation satellite missions, and where/how to access the data.

## Slide 2 – A golden age

You may not realize it, but we are currently living in a golden age for satellite imagery. This diagram shows a number of different optical satellite programs since the early 1970s, when Earth observation satellite missions started. For the first 10-15 years or so, there wasn't very much available. We really only had the different Landsat missions up until about 1986, with the launch of the first French Satellite Pour l'Observation de la Terre (SPOT-1). Around 2000, we added a few more sensors, including ASTER and MODIS, along with IKONOS, one of the first really high-resolution imaging satellites. And then, after about 2010 or so, the number of satellites acquiring data really exploded. But the thing that makes this a golden age is not just the number of satellites acquiring data. Some of these, especially the really high-resolution sensors such as the different WorldView satellites, SPOT, and Pléiades, are also extremely expensive images – to be able to look at large areas over a longer period of time, you have to have a lot of money. No, what makes this a truly golden age for satellite data is that beginning in 2008, the US Geological Survey opened the Landsat archive up. From that time on, any and all Landsat images acquired by the USGS are available, for free, to anyone. Beginning in 2016, NASA did the same thing for the ASTER archive. From the moment it launched, Sentinel-2 data have been freely available to anyone. We have 40+ years of satellite images that are freely available, which has truly transformed remote sensing studies. Before 2008, most studies would be able to use a few images, which places some limits on the things we can hope to see with remote sensing. Since 2008, we've had studies that have used thousands, or tens of thousands, or hundreds of thousands, of images – and it has completely transformed the things we can observe using remote sensing.

## Slide 3 – The Landsat program

We'll begin with the Landsat program, which is the flagship Earth-observation satellite program. It began in 1972 with the launch of Earth Resources Technology Satellite-1, or ERTS-1, which was later renamed Landsat 1. It is run jointly between the US Geological Survey and NASA, and it has consisted of a number of different sensors. Landsat 1-5 carried the Multispectral Scanner, which had 4 bands in the visible and near infrared wavelengths. Landsat 4-5 also had a band in the thermal wavelengths. The second sensor was the Thematic Mapper, which was carried by Landsat 4 and 5. After that came the Enhanced Thematic Mapper Plus, which was carried by Landsat 6 and 7, though Landsat 6 failed to reach orbit on launch in 1993. Finally, we come to the Operational Land Imager and the Thermal Infrared Sensor, both carried by Landsat 8. As I mentioned before, the whole archive has been free since 2008, marking nearly 50 years of observations, with more coming in daily, and the launch of Landsat 9 planned for sometime next year.

## Slide 4 – The Landsat program

Landsat 4-8 has 16-day repeat coverage, meaning that every 16 days, the satellite covers the same area on the Earth. The MSS instrument had approximately 60 m spatial resolution for all of its bands, and a 185 km swath width. The TM, carried by Landsat 4 and 5, had 7 bands, 4 in the visible and NIR, 2 in the SWIR, and 1 in the Thermal Infrared. The thermal band had a spatial resolution of 120 m, while the other 6 bands had a spatial resolution of 30 m. The ETM+ was nearly identical to the TM, though it added a panchromatic band with 15 m spatial resolution. Each of these sensors were optical-mechanical scanners, or whiskbroom sensors, and they all have a radiometric resolution of 8 bits – that is, each band has a total of 256 possible gray values. The operational land imager and thermal infrared sensor carried by Landsat 8 are pushbroom instruments, and they have a radiometric resolution of 12 bits (4096 gray values). In addition to the 30 m visible, NIR, and SWIR and 15 m panchromatic bands, OLI also has a “coastal and aerosol band” and a “cirrus” band, which are used for studying atmospheric aerosols, coastal areas, and clouds, each with 30 m spatial resolution. The TIRS sensor has two separate thermal bands with 100 m spatial resolution.

## Slide 5 – ASTER

The Advanced Spaceborne Thermal Emission and Reflection Radiometer, or ASTER, is a joint mission shared by NASA and the Japanese Space Agency. It was launched in December 1999 aboard NASA’s Terra satellite, and it began acquiring images in March 2000. The sensor consists of three systems: The Visible/NIR system with 3 bands at 15 m spatial resolution; the Shortwave Infrared system, with 6 bands at 30 m, stopped working in 2008. And the Thermal Infrared system, with 5 bands at 90 m resolution. ASTER also acquires stereo images in the near-infrared, which allow for calculating topography. And, like Landsat, the ASTER archive was made freely available from April 2016, providing a time series of over 20 years of global elevation, as well as elevation change. This allows us to study things like glacier melt, but potentially also deforestation, large-scale erosion,

## Slide 6 – Sentinel-2 MSI

Sentinel-2 is a part of the EU’s Copernicus Programme, operated by the European Space Agency. It was first launched in 2015, and since 2017, has been a tandem mission of two satellites. This provides approximately 5 day repeat coverage of the globe. The instrument on board Sentinel-2 is the Multispectral Instrument, which provides a number of different resolutions. The 4 Visible and NIR bands have a spatial resolution of 10 m, while 6 SWIR, and Red Edge bands have a spatial resolution of 20 m. The Coastal Aerosol, Water vapor, and 2 cirrus bands each have a resolution of 60 m. Like Landsat and ASTER, Sentinel-2 data are provided for free.

## Slide 7 – Summary

In this lesson, we’ve learned that there is an unprecedented amount of global, freely-available data, with more images coming in daily. This explosion of data has changed the ways that we use remote sensing to study Earth’s environment and processes.

The archived data stretch back to 1972, with pretty good global coverage starting from about 1985 onward.

After 2000, multiple sensors and missions are available, with near-simultaneous coverage, greatly increasing the number of images available.

## **Slide 8 – Additional Information**

For each of the missions I've covered in detail here, I've linked to the official mission website, where you can find more information about the sensor(s), satellites, data, and so on. If you're interested in learning more about a particular sensor or mission, I suggest that you start there. That's all for this lesson – I hope you found it interesting, and if you have any questions, please don't hesitate to e-mail me or post in the discussion forum on blackboard. Bye!