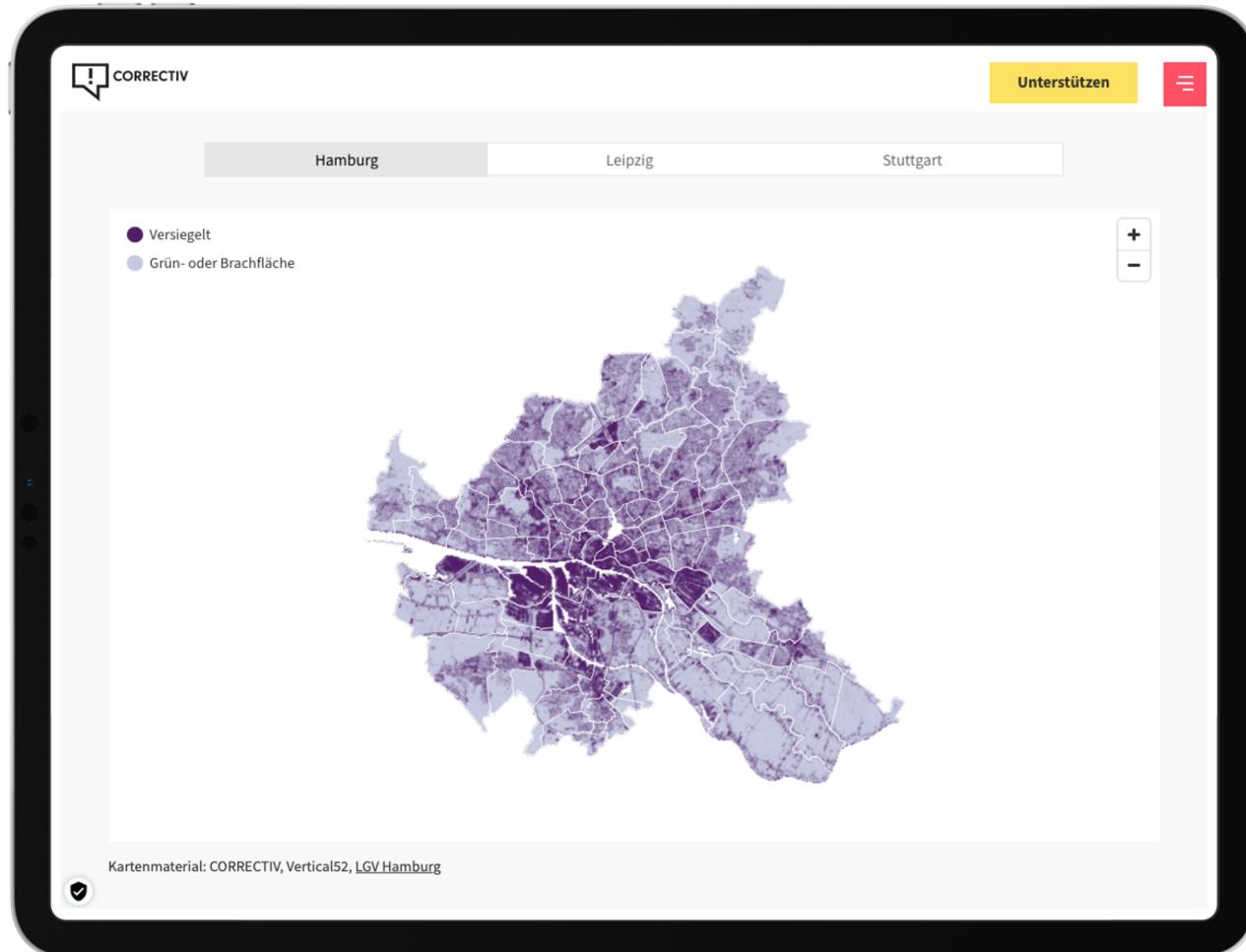


Exploring extreme heat

Satellite imagery and raster analysis in R





How is heat measured?

Beyond the weather report

Beyond the weather report

How is heat measured?



Image credits: Corvinus University of Budapest

Surface air temperature

~ 2m off the ground, used in weather reports, closer to what we feel

Land surface temperature (LST)

Strongly influenced by material, can be hotter/cooler than air temperature due to thermal mass

Beyond the weather report

The urban heat island effect

Materials such as **brick**, **concrete**, **asphalt** and **pavement** have higher thermal mass.

This means they **absorb and store heat** throughout the day.

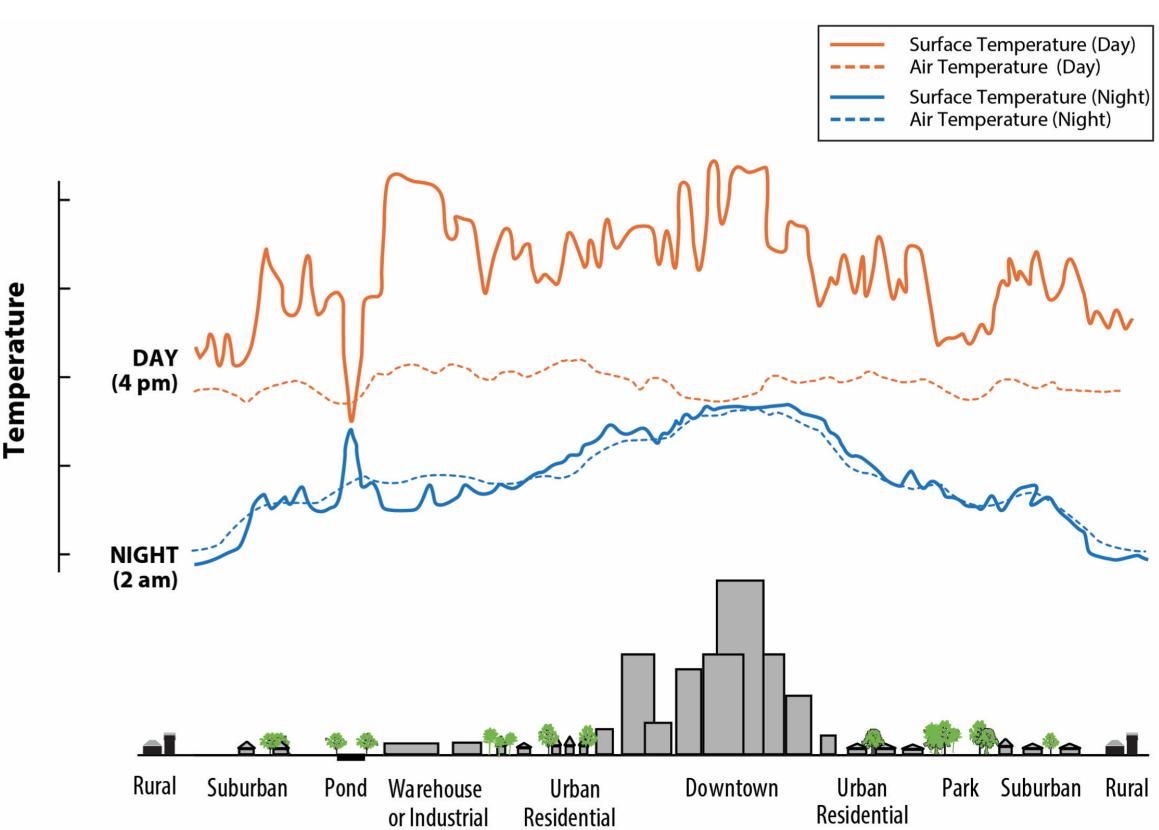


Image credits: EPA

Which metric is better to use?

Surface air temperature

- Reflects „felt“ temperature
- Directly measured via weather stations, sensors and other on-site instruments
- Measurements are continuous throughout the day, regardless of weather conditions

- May not be representative of the surrounding geographic area
- Sensors may not be consistent (height, direction, etc.)

Land surface temperature

- Measured via satellites, aircrafts or ground-based thermal sensing
- Better geographic coverage
- Shows the direct impact of sealing in urban areas

- Clouds, trees and tall buildings can limit usability
- Temporal and spatial resolution often dependent on third party providers, higher resolution data can be costly

02

How to access free, high quality satellite imagery

Getting started with Landsat

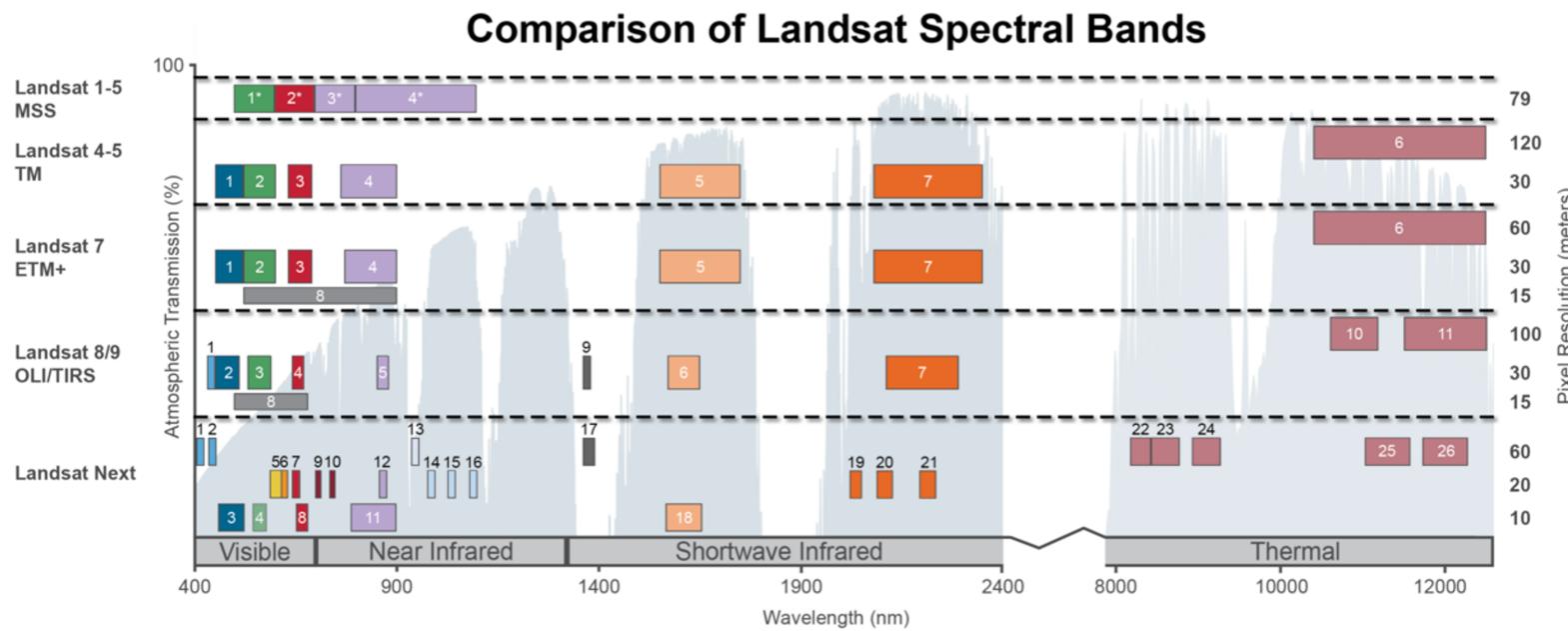
What is the Landsat satellite program?

- Series of **Earth-observing satellite missions** jointly managed by NASA and the U.S. Geological Survey.
- Optimized for **tracking land use and changes** due to **climate change, urbanization, droughts, wildfires**, and more.
- World's longest continuous archive of satellite imagery: **1972 to present**
- **It's also free.**

Getting started with Landsat

How do satellites measure surface temperature?

Satellites can record a large range of waves in the electromagnetic spectrum...



Getting started with Landsat

Understanding spatial and temporal resolution

Spatial resolution

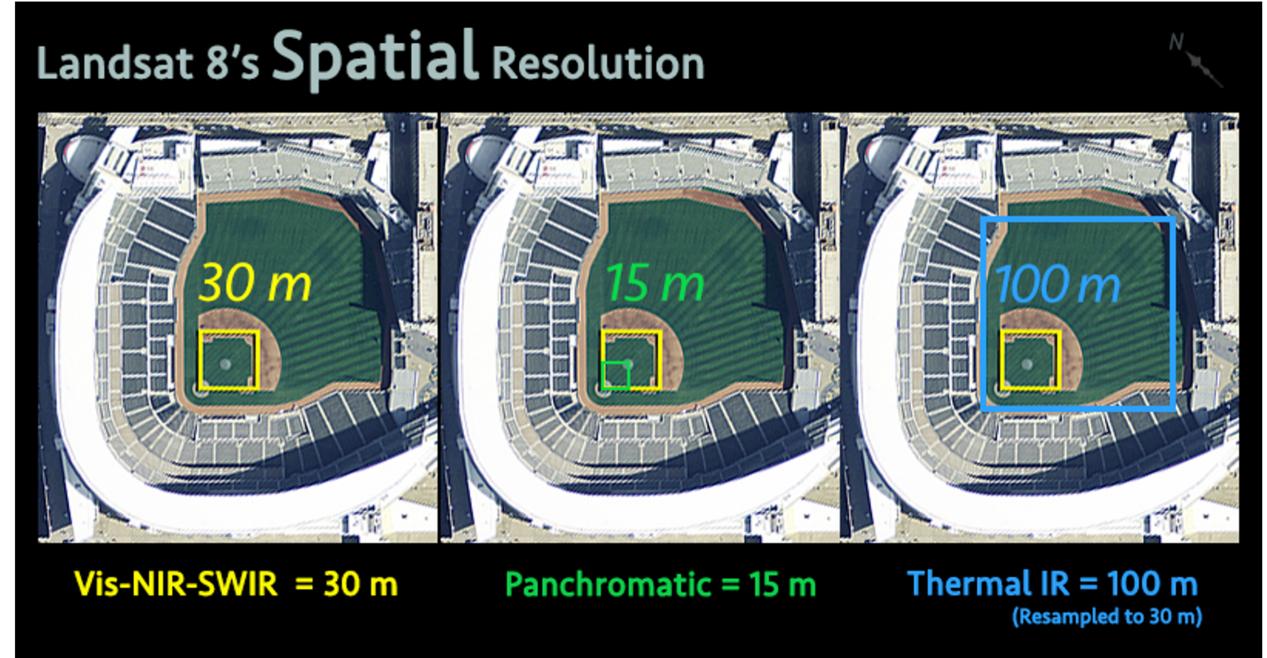
How „clear“ an image is

Landsat: 15 - 100 meters

Temporal resolution

How often an image is taken

Landsat: Every 16 days



Landsat's data structure

Collection 1

Legacy processing with lower accuracy; retired 2022

Collection 2 Level-1

Improved accuracy, raw satellite measurements

Collection 2 Level-2

Analysis-ready, corrected for atmospheric effects, but due to use of auxiliary data slightly more limited coverage

What's a (Geo)TIFF file?

Tagged Image File Format (TIFF)

Contains raster graphic images. Uses lossless compression, which is good for large file sizes and preserving high-quality data.

GeoTIFF

Combines a TIFF image with embedded geographic metadata.

The embedded metadata specifies the image's coordinate reference system (CRS), map projection, and how the image data corresponds to real-world coordinates.

Getting started with Landsat

Landsat: What you get

One TIFF file per band (red/green/blue/near infrared/thermal infrared/surface temperature/etc.)

Bands	Wavelength (micrometers)	Resolution (meters)
Band 1 - Coastal aerosol	0.43–0.45	30
Band 2 - Blue	0.45–0.51	30
Band 3 - Green	0.53–0.59	30
Band 4 - Red	0.64–0.67	30
Band 5 - Near Infrared (NIR)	0.85–0.88	30
Band 6 - Shortwave Infrared (SWIR) 1	1.57–1.65	30
Band 7 - Shortwave Infrared (SWIR) 2	2.11–2.29	30
Band 8 - Panchromatic	0.50–0.68	15
Band 9 - Cirrus	1.36–1.38	30
Band 10 - Thermal Infrared (TIRS) 1	10.6–11.19	100 (resampled to 30)*
Band 11 - Thermal Infrared (TIRS) 2	11.50–12.51	100 (resampled to 30)*

Plus: Quality assessment bands

Landsat file naming conventions

LXSS_LLLL_PPPRRR_YYYYMMDD_yyyymmdd_CC_TX

Where:

- L = Landsat
- X = Sensor (“C”=OLI/TIRS combined, “O”=OLI-only, “T”=TIRS-only, “E”=ETM+, “T”=TM, “M”=MSS)
- SS = Satellite (“07”=Landsat 7, “08”=Landsat 8)
- LLL = Processing correction level (L1TP/L1GT/L1GS)
- PPP = WRS path
- RRR = WRS row
- YYYYMMDD = Acquisition year, month, day
- yyyymmdd – Processing year, month, day
- CC = Collection number (01, 02, ...)
- TX = Collection category (“RT”=Real-Time, “T1”=Tier 1, “T2”=Tier 2)

Example: LC08_L1GT_029030_20151209_20160131_01_RT

Means: Landsat 8; OLI/TIRS combined; processing correction level L1GT; path 029; row 030; acquired December 9, 2015; processed January 31, 2016; Collection 1; Real-Time

Let's get started!

Posit Cloud:

We will write on the board ☺

GitHub:

<https://github.com/maxdonheiser/dh25-landsat-R>

Thank you!

Max Donheiser

Tagesspiegel Innovation Lab

Jonathan Stoneman

Arena for Journalism in Europe

GitHub Repo

[maxdonheiser/dh25-landsat-R](https://github.com/maxdonheiser/dh25-landsat-R)