GEOS 639 – INSAR AND ITS APPLICATIONS

GEODETIC IMAGING AND ITS APPLICATIONS IN THE GEOSCIENCES

Lecturer:

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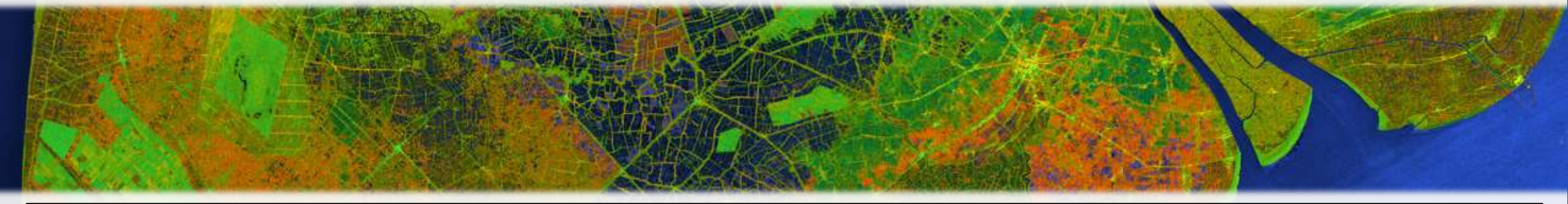
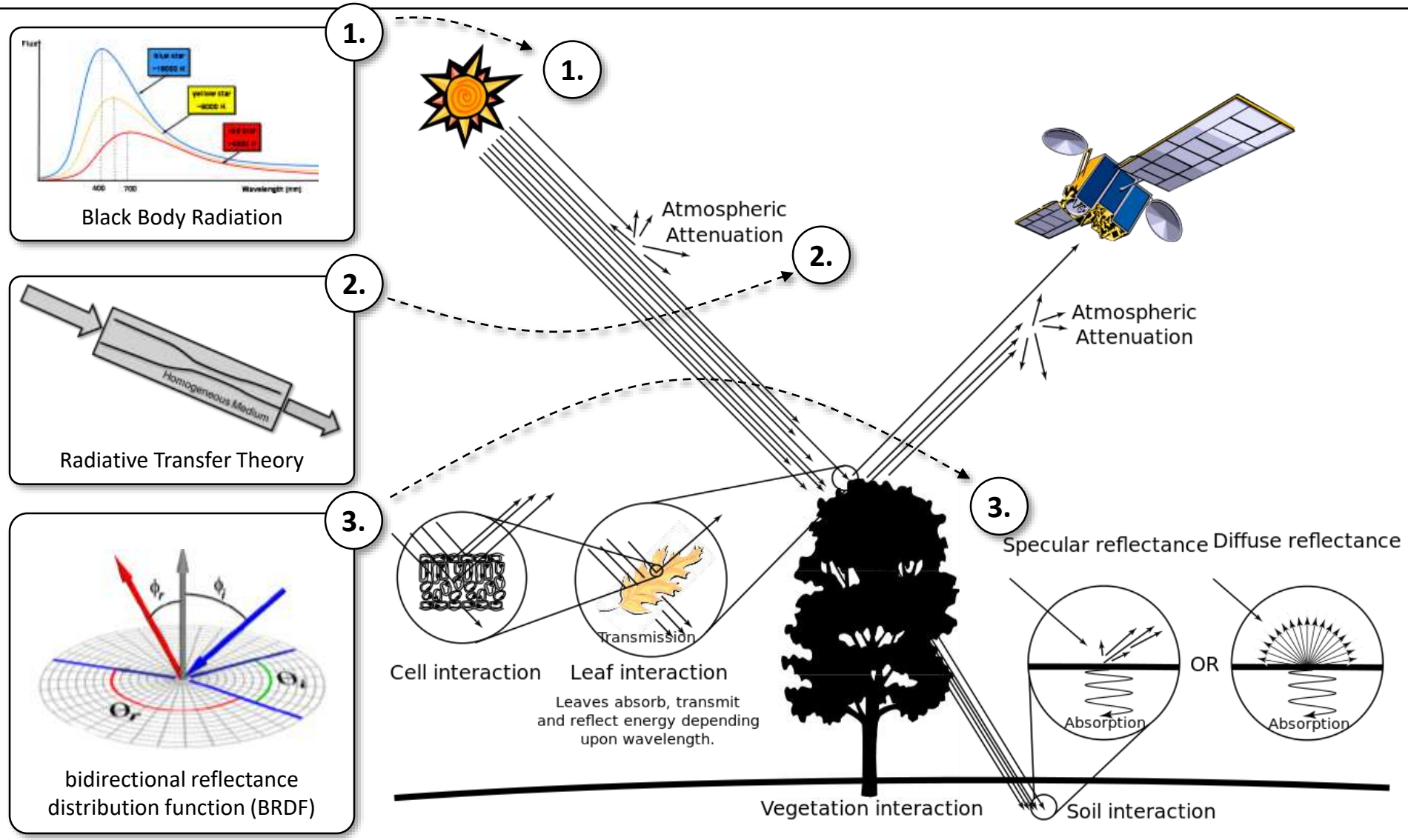
Lecture 3: Introduction to Geodetic Imaging II - Optical Remote Sensing



Sensor Types Relevant for this Course

Optical Remote Sensing Systems

The Genesis of an Electro Optical Image



Relevant Sensor Parameters

1. **Spatial resolution**
   - Ability to separate parts of targets or other properties pertinent to RS

2. **Spectral resolution**
   - location, width and sensitivity of chosen λ bands

3. **Temporal sampling**
   - time between observations

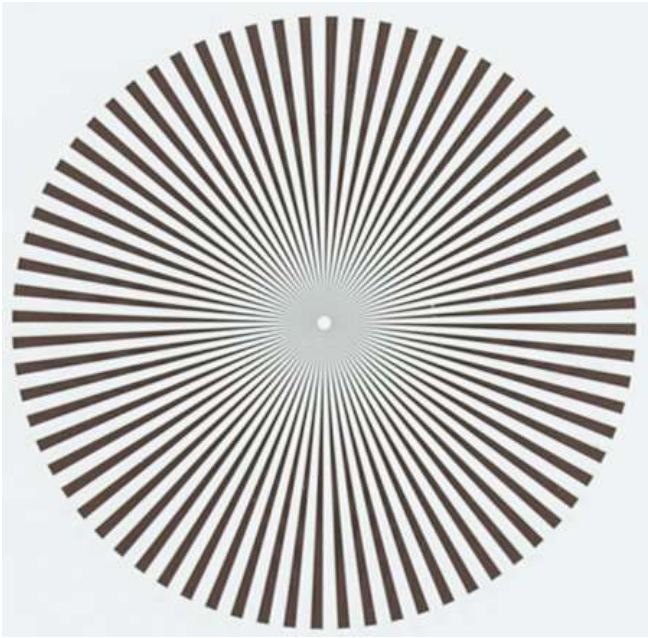
4. **Radiometric resolution**
   - Sensitivity of the sensor to incoming radiance

1. Spatial Resolution

- **Minimum distance at which two objects can still be distinguished**
- The smallest quantity measurable in an image

- **Measuring spatial resolution of image data:**
  - Calibration targets:

Calibration Site in Sjökulla, Finland



Siemens Star Calibration Target

1. Spatial Resolution

Spatial Resolution vs. Pixel Size

Resolution vs. Pixel Size

Resolution: 10m
Pixel size: 10m

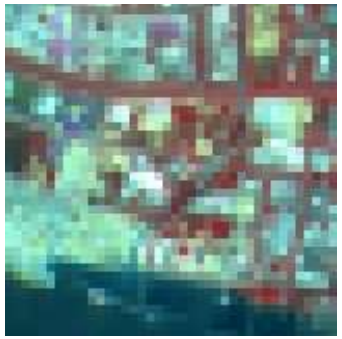
Resolution: **30m**
Pixel size: 10m

Resolution: **80m**
Pixel size: 10m

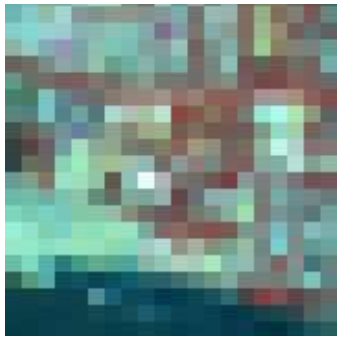
Resolution and visual appearance of images

Pixel size & res: 10m
160×160 pixels

Pixel size & res: **20m**
80×80 pixels



Pixel size & res: **40m**
40×40 pixels

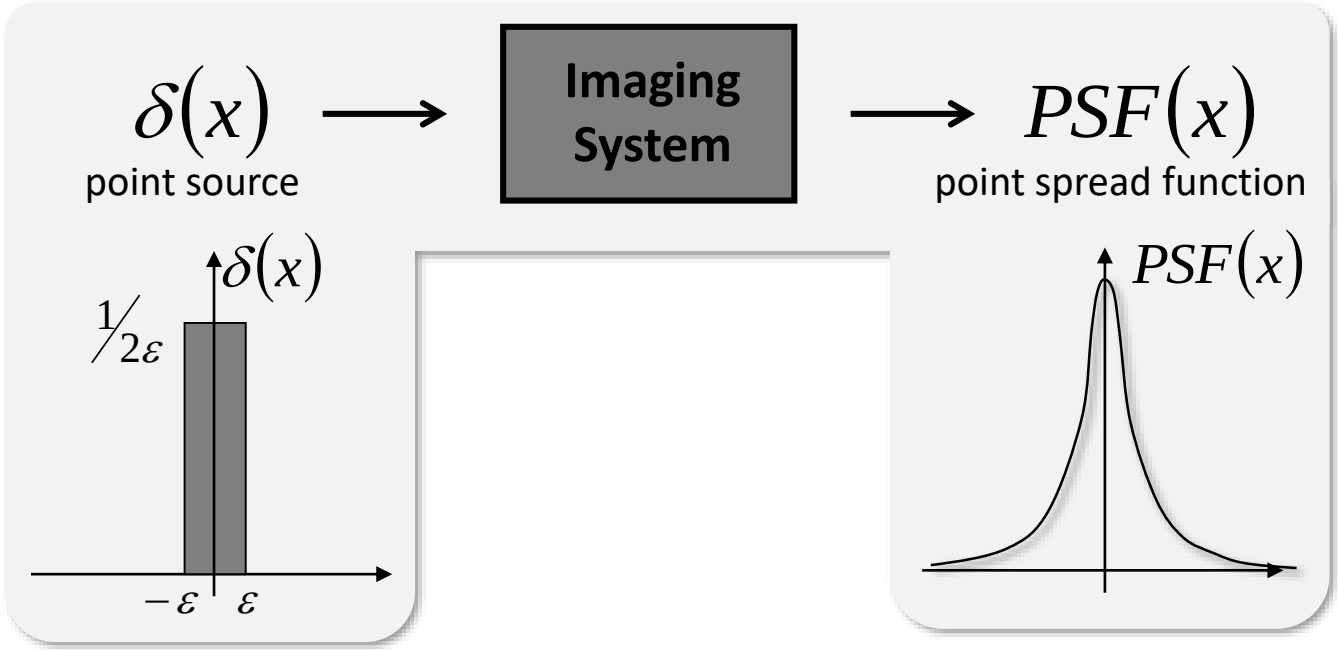


Pixel size & res: **80m**
20×20 pixels

1. Spatial Resolution

Point Spread Function

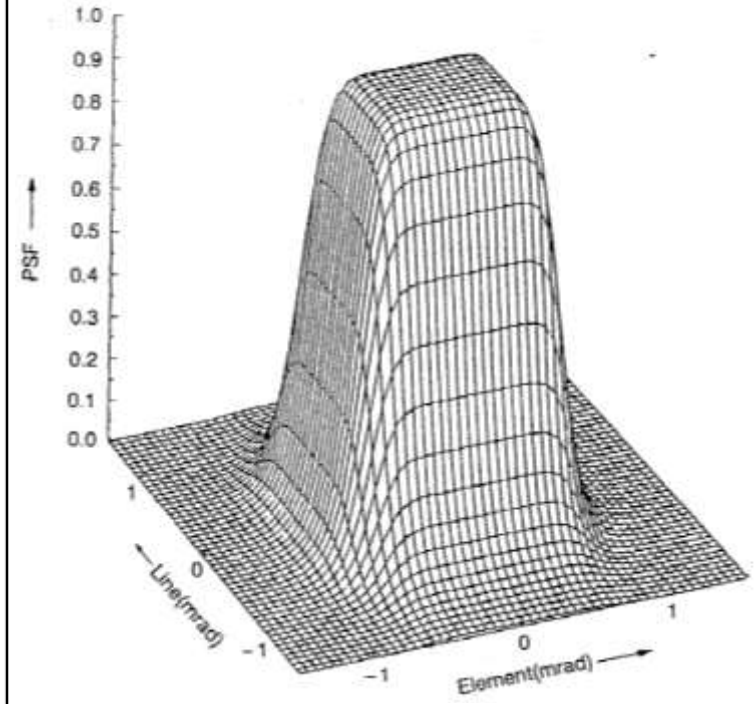
- **Point Spread Function**: Response of imaging system to a point source stimulant



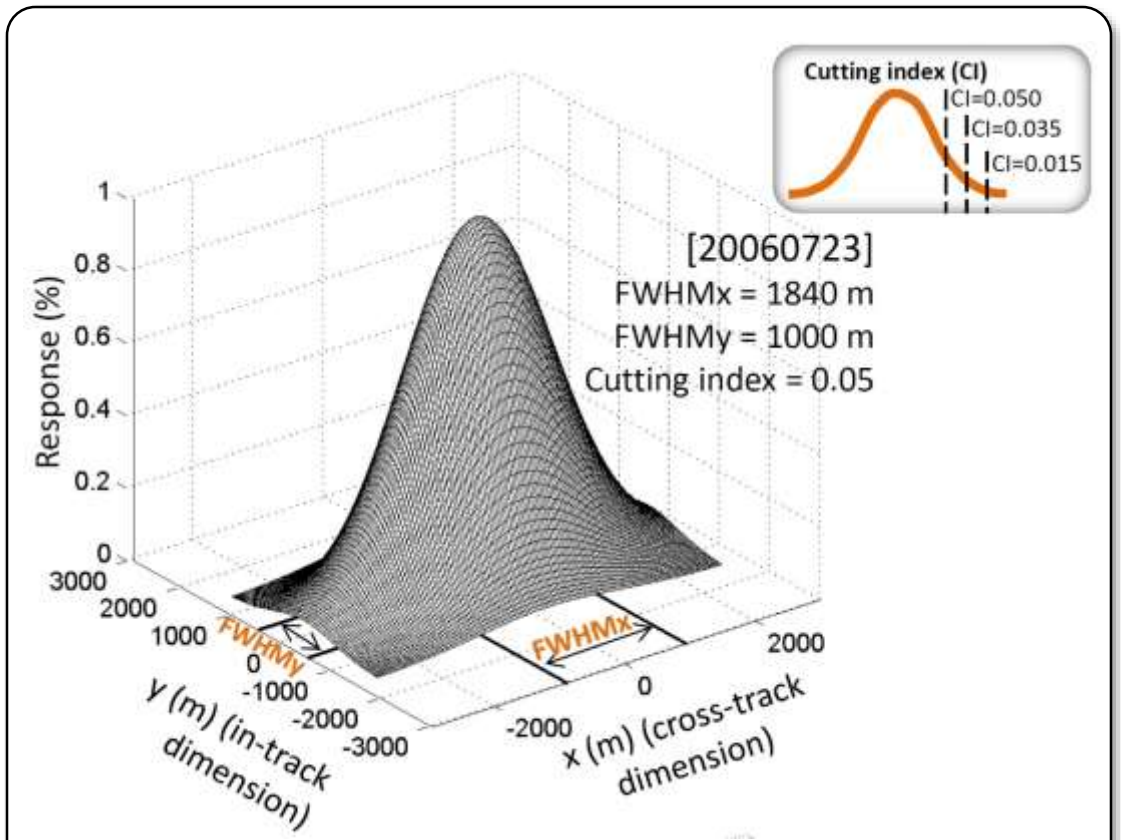
- **Idealized case**: pixel response is same as source impulse $\delta(x)$
- **In practice**: each pixel responds imperfectly to input signal (→ $\delta(x)$ deteriorates to a broader $PSF(x)$)

1. Spatial Resolution

Point Spread Function of Real Sensors



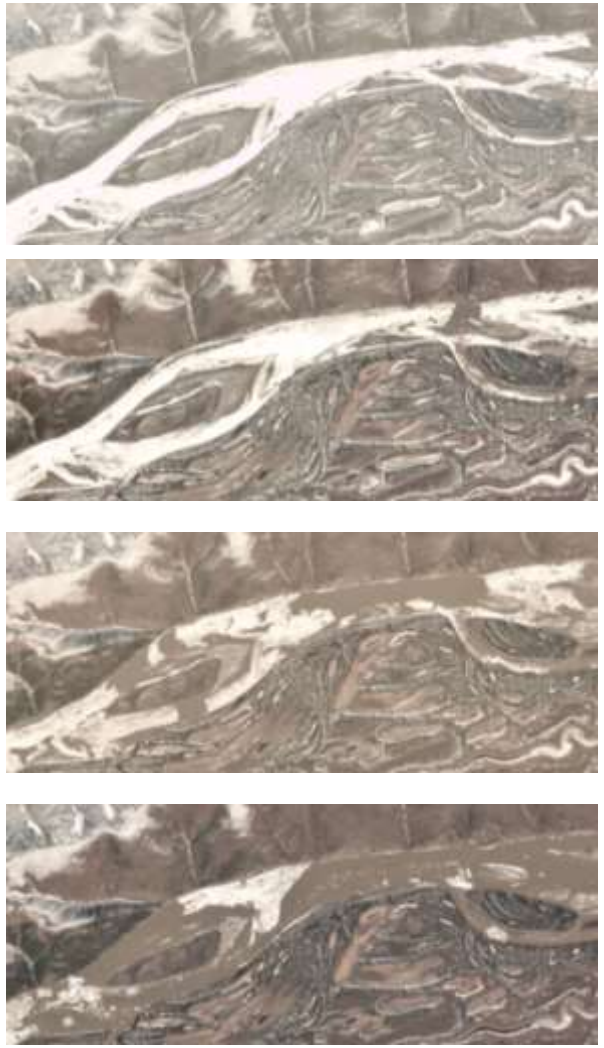
Example PSF of AVHRR Sensor



Average PSF of MODIS Bands 8 - 19

3. Temporal Sampling

Repeat period crucial for resolving dynamic processes



May 27, 2019

May 28, 2019

May 29, 2019

May 30, 2019

64.12N, 158.56 W

Ice break-up
Tanana River

planet.

Cubesat constellation: daily coverage

Think – Pair – Share

Temporal Sampling and Feature Tracking

- You want to develop an algorithm to measure the velocity of glacier flow using a time series of Landsat imagery such as the data to the right
  - **Q1**: What approach would you use to measure glacier flow from this time series
  - **Q2**: How may the temporal sampling provided by Landsat influence your algorithm design?

4. Radiometric Resolution

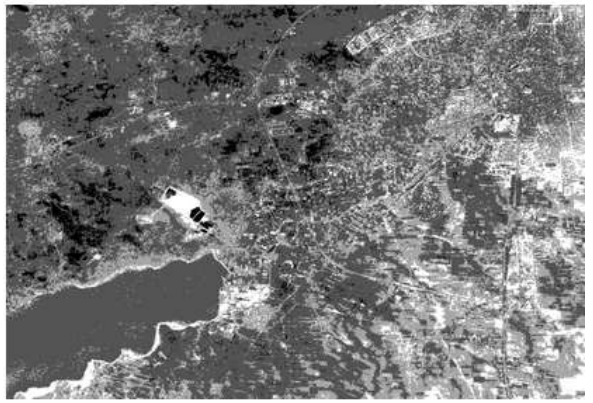
- Sensitivity of measurement

  Smallest change in intensity that can be distinguished

16 Values (4 bit)

- Digital images

  # bits often referred to as radiometric resolution

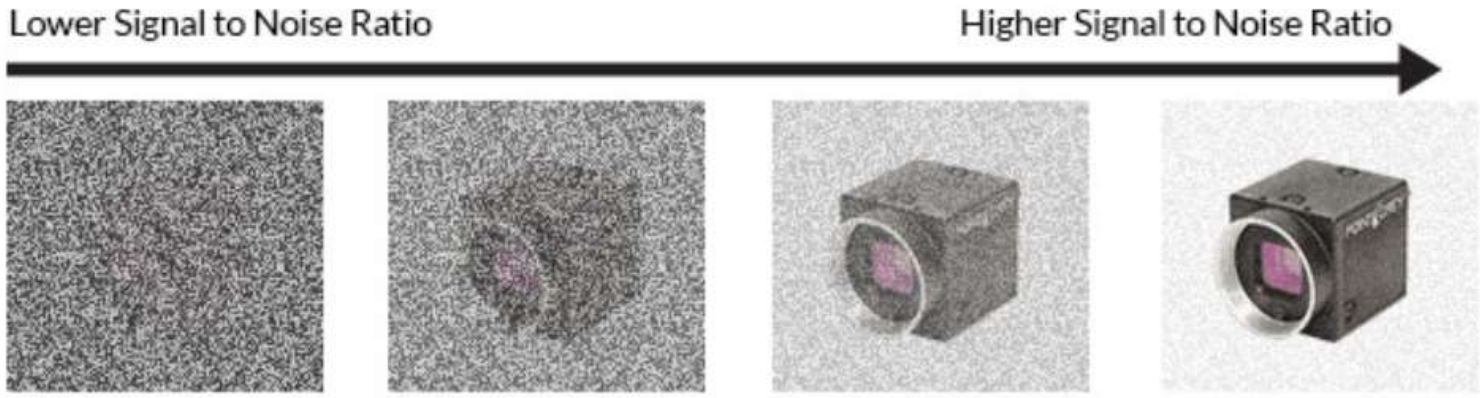


4 Values (2 bit)

Signal to noise ratio

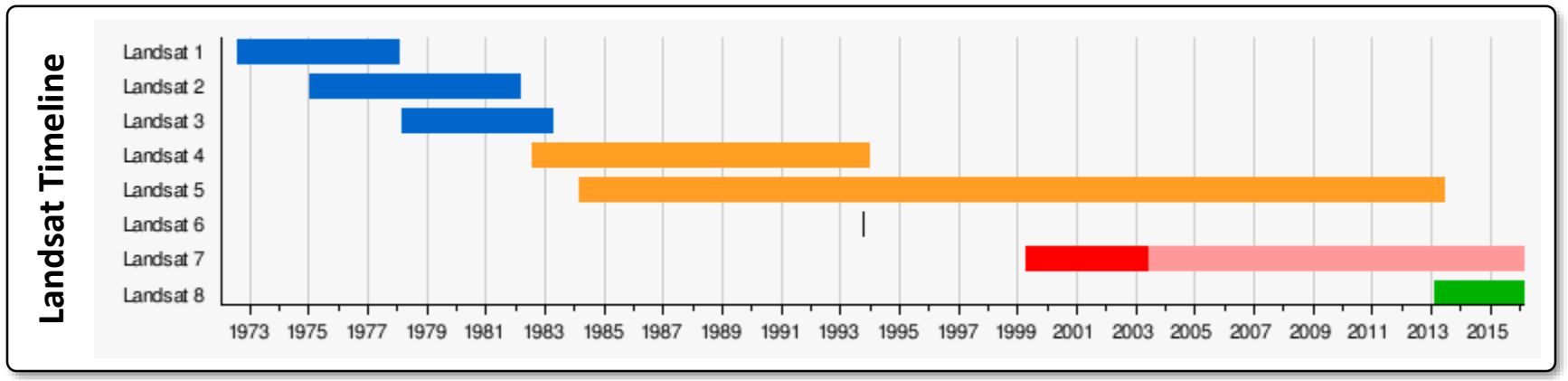
A complementary way of describing measurement fidelity

$$SNR\ [dB] = 10 \log_{10} \frac{P_{signal}}{P_{noise}}$$



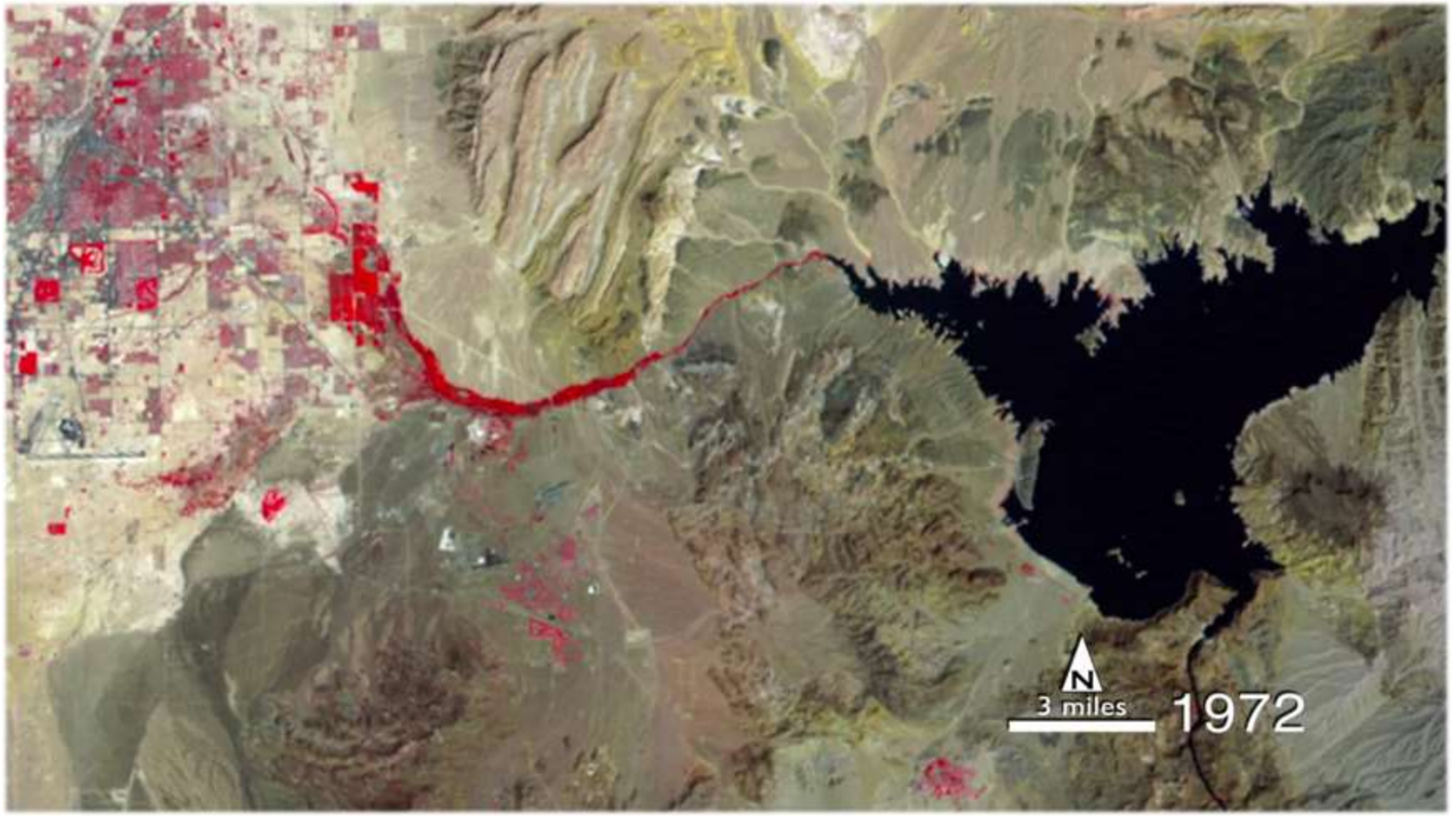
The Landsat Program

- **Landsat 1**: 1972 – 1978
- **Landsat 2**: 1975 – 1981
- **Landsat 3**: 1978 – 1983
- **Landsat 4**: 1982 – 1993
- **Landsat 5**: 1984 – 2013
- **Landsat 6**: 1993, failed to reach orbit
- **Landsat 7**: 1999, still functioning, but with faulty scan line corrector (May 2003)
- **Landsat 8**: 2013, still active
- **Landsat 9:** Launched 2021



Benefit of the Long Landsat Time Series

- **Example:** Urban Growth of Las Vegas (and Effects on Lake Mead)



The DigitalGlobe High-Resolution Commercial Imaging Systems

- DigitalGlobe is the commercial vendor for the following high-res satellite systems:
  - EarlyBird-1
  - IKONOS
  - QuickBird
  - GeoEye-1
  - WordView-1 to -3

- All systems focus on high resolution (meter to sub-meter) and offer multispectral imaging capabilities with up to 8 bands between VIS and near IR.

WordView-3 Image

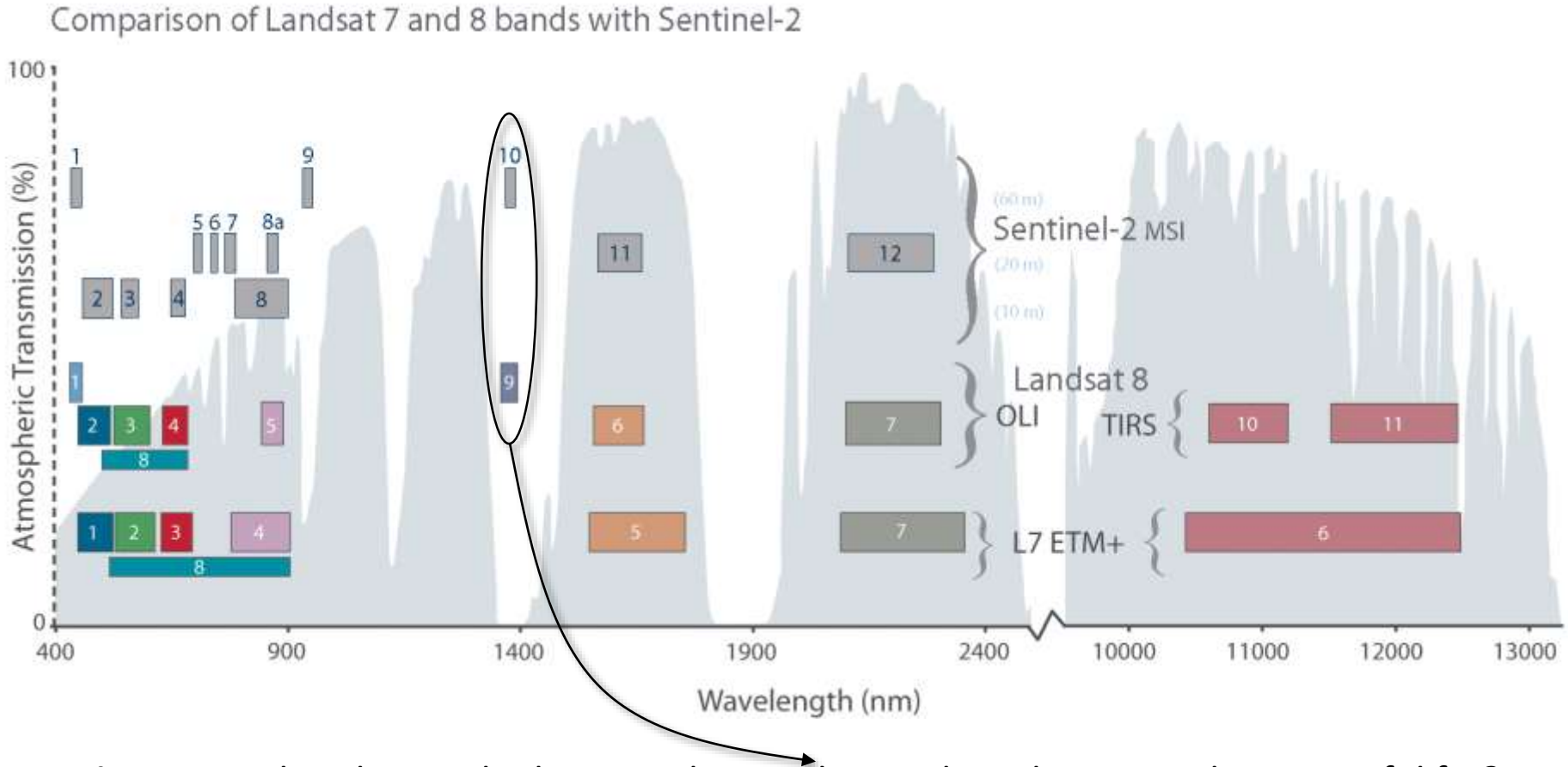
King Abdullah Petroleum Studies and Research Center

Sentinel-2

ESA's new & freely available VIS and IR resource

Sentine-2 vs. Landsat-7 and -8

Spectral Bands



Question: What do you think Sentinel-2 Band 10 and Landsat-8 Band 9 are useful for?

Answer: They are used for mapping Cirrus clouds (high altitude clouds)

Want to Know More?

For a Deeper Dive Into Optical Remote Sensing:

Register for GEOS 654 Visual and Infrared Remote Sensing

Reading Assignment

- Next Lecture: Intro. To Geodetic Imaging – Synthetic Aperture Radar

- To prepare for this upcoming lecture, continue reading:

SAR Handbook Chapter 2: SAR Principles, Data Access, and Basis Processing Techniques [Meyer, 2019]

Chapters 2.1 and 2.2

QUESTIONS?