ERASMUS-EDU-2023-CBHE
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LESLIE
LAND MANAGEMENT ENVIRONMENT & SOLID-WASTE

MICRO-CREDENTIAL

LAND MANAGEMENT IN CENTRAL ASIA

10.- Introduction to Remote Sensing

Definition and Scope of Remote Sensing

LM-W10-V64

Co-funded by the European Union

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What remote sensing is?

Definition, direct meaning, and relation to field observation

Core idea

Remote sensing is the collection of information about an object, area, or process without direct physical contact, usually by recording reflected or emitted energy with a sensor.

Remote sensing

The observer does not need to stand on the target.
Examples: satellite image, drone image, radar scene.

In situ data

The observer or instrument is placed on or very near the target.
Examples: field sampling, thermometer, soil probe.

Energy reaches the target → Sensor records the signal → We interpret the data

Remote sensing is wider than satellite imagery: it also includes airborne and some ground-based systems.

Why remote sensing matters

From observation to management and decision support

Large-area coverage

One scene can show fields, rivers, settlements, and terrain together.

Repeated monitoring

The same place can be observed again and again to detect change.

Access to difficult areas

Useful for deserts, mountains, floods, or politically sensitive areas.

Decision support

Supports mapping, analysis, and evidence-based planning.

Why universities and agencies use it

Remote sensing connects observation with action. It helps us estimate crop condition, monitor water bodies, map land cover, check environmental stress, and support planning with evidence that is spatially explicit and repeatable.

Land
Water
Agriculture
Environment

Electromagnetic radiation and energy interaction

Remote sensing depends on how energy moves and changes

Source — Sun or sensor

Atmosphere — Scattering and absorption

Target — Reflect, absorb, transmit, emit

Sensor — Records the returning signal

Processing — Correct and organize data

Use — Map, classify, monitor

Key interactions

Different materials respond differently to energy. Water, soil, vegetation, built surfaces, and snow do not return the same signal.

Why atmosphere matters

Before and after touching the ground, energy can be scattered or absorbed by gases, aerosols, and clouds.

Why this matters in practice

Image quality and interpretation depend on wavelength, weather, surface condition, and sensor design.

Platforms: ground, airborne, and satellite

Different platforms produce different scales and different kinds of information

Ground-based platforms

Close-range observation from towers, tripods, vehicles, or field instruments.

Strengths:
- very high detail
- strong calibration link

Typical use: site studies and validation.

Airborne platforms

Aircraft, helicopters, and drones carry cameras, multispectral sensors, LiDAR, or radar.

Strengths:
- flexible timing
- high spatial detail

Typical use: urban mapping and precision agriculture.

Satellite platforms

Spaceborne systems observe large areas repeatedly from orbit.

Strengths:
- broad coverage
- repeat observation

Typical use: land cover, water, and drought monitoring.

General trade-off: closer platforms usually provide higher detail, while higher platforms usually provide greater coverage and more repeat observation.

Sensors: passive and active

The key difference is whether the system uses natural energy or its own energy

Passive sensing

Uses natural reflected or emitted energy.

Examples:
- optical camera
- multispectral scanner
- thermal sensor

Best for: rich spectral land and vegetation analysis.

Limitation: reflected-light systems depend on illumination and are often blocked by clouds.

Active sensing

Generates its own signal and measures the return.

Examples:
- radar or SAR
- LiDAR

Best for: day-and-night observation, many cloudy conditions, and structure or elevation analysis.

Limitation: interpretation is often less intuitive for beginners.

Practical rule: passive systems often give a familiar image-like view, while active systems are powerful when lighting or cloud cover is a problem.

Four kinds of resolution

Resolution determines how much detail, difference, and change a dataset can show

Spatial resolution

Pixel size on the ground. Smaller pixels show finer detail. Example: a 10 m pixel usually shows more local detail than a 30 m pixel.

Spectral resolution

Number and width of wavelength bands. More and narrower bands improve material discrimination.

Radiometric resolution

Sensitivity to small differences in energy. An 8-bit system stores $2^8 = 256$ levels.

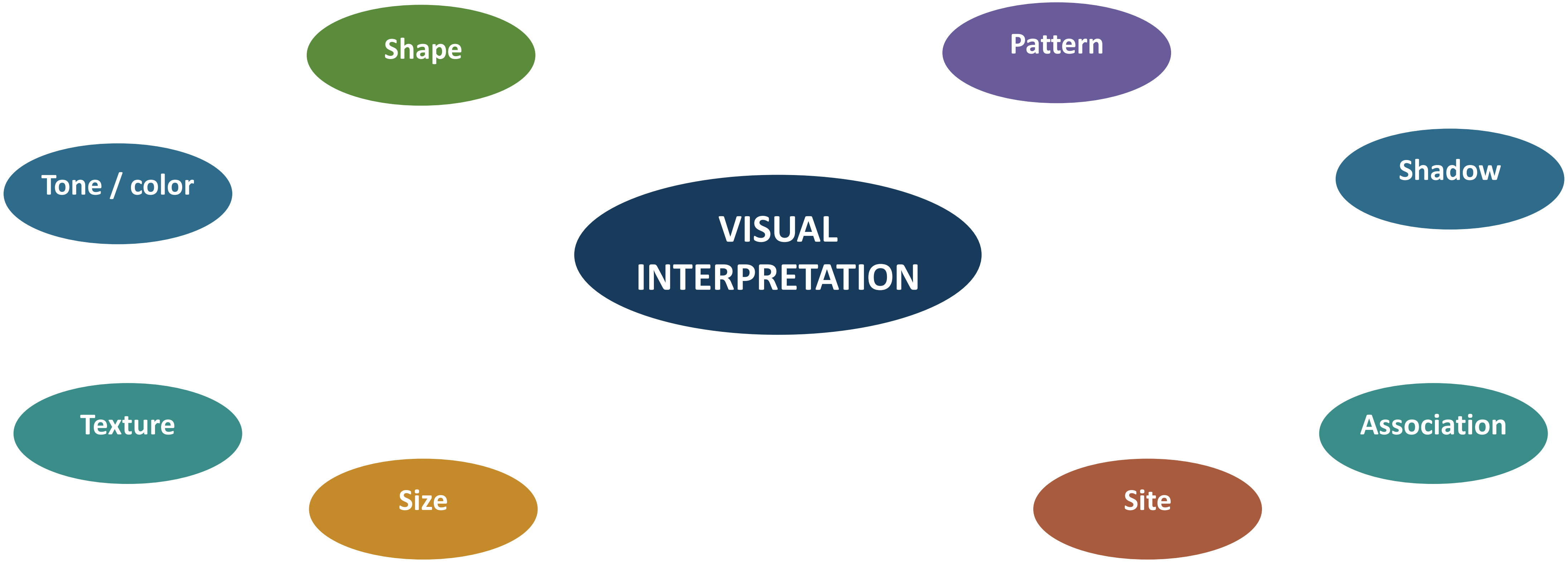
Temporal resolution

How often the same place is observed. Sentinel-2 combined revisit is 5 days.

Important trade-off: a system rarely maximizes spatial, spectral, radiometric, and temporal resolution all at the same time. Sensor design always involves compromise.

Image interpretation basics

How beginners learn to read patterns in remotely sensed images



Example: circular fields often suggest center-pivot irrigation; straight linear features may suggest roads, canals, or boundaries.

Common data products and processing concepts

Remote sensing becomes useful after correction, analysis, and interpretation

Acquisition
Raw image or signal

Pre-processing
Geometric and radiometric correction

Enhancement
Composite, contrast, filtering

Analysis
Index, classification, change detection

Output
Map, model, report, decision support

Common optical products

True color, false color, band combinations, mosaics, orthoimages.

Derived products

Vegetation indices, land surface temperature, land cover classes.

Integrated products

Digital elevation models, suitability maps, change maps, GIS layers.

Major application areas

Remote sensing is useful because it supports many sectors with one observation framework

APPLICATIONS

Land management
Land cover mapping, erosion signs, land use change.

Water resources
Surface water extent, snowmelt support, reservoir monitoring.

Agriculture
Crop condition, irrigation timing, stress detection.

Environment
Wetlands, fire scars, pollution indicators, habitat change.

Planning and infrastructure
Urban growth, corridor analysis, hazard-sensitive siting.

Regional relevance: remote sensing in Central Asia

The same principles become especially valuable in dryland and mountain environments

Irrigation and canal systems

Track irrigated area, field condition, and uneven water delivery.

Salinity and land degradation

Identify stressed land, bare surfaces, and long-term change.

Snow, glaciers, and runoff

Monitor seasonal water sources in mountain catchments.

Drought and rangelands

Observe vegetation condition, pasture pressure, and dry-season stress.

Aral Sea, wetlands, and dust-prone areas

Track shoreline change, exposed surfaces, and environmental risk zones.

For Central Asian teaching, remote sensing is especially useful because many key problems are spatial, seasonal, and difficult to monitor only from field visits.

Advantages of remote sensing

Why the method is so widely used in science, management, and education

- Broad spatial coverage
- Repeat observation through time
- Consistent digital records for comparison
- Multi-sensor and multi-scale analysis
- Strong integration with GIS, field data, and modeling

In practice, the strongest advantage is not a single image. It is the ability to combine repeated observations with other spatial data.

Limitations and practical challenges

Remote sensing is powerful, but good results require careful choice and careful interpretation

Challenge	Why it matters	Common response
Clouds and atmosphere	Optical scenes may be blocked or altered before the signal reaches the sensor.	Use radar, multi-date images, or atmospheric correction.
Resolution trade-offs	One dataset may be strong in one type of resolution but weak in another.	Choose data based on the question, not on popularity alone.
Need for field validation	Images can suggest patterns, but field data helps confirm meaning.	Combine remote sensing with in situ observation and local knowledge.
Processing and skills	Good analysis needs software, method choice, and quality control.	Use clear workflows and document assumptions.
Interpretation uncertainty	Different surfaces can look similar under some conditions.	Use multiple dates, bands, and contextual clues.

Integrated review of key concepts

A simple chain for understanding how remote sensing works

1. Define the question
What do we need to know?

2. Choose platform and sensor
Ground, airborne, satellite; passive or active

3. Check resolution
Spatial, spectral, radiometric, temporal

4. Process and interpret
Correct, enhance, classify, compare

5. Apply the results
Map, monitor, evaluate, decide

Four review questions

- What exactly is being measured: reflected energy, emitted energy, or an active return?
- Which platform and sensor best match the task?
- Which resolution matters most for this question?
- How will the image become an interpretable product for a real decision?

Conclusion and references

Key message: remote sensing is a measurement-based way to observe Earth from a distance

Conclusion

Remote sensing allows us to observe the Earth without direct contact by measuring reflected, emitted, or actively returned energy.

Its value comes from repeated observation, large-area coverage, and its ability to support land, water, agriculture, environmental monitoring, and planning.

For deeper study, review the references and compare the concepts from this lecture with real datasets and practical exercises.

Selected references

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- U.S. Geological Survey. What is radiometric resolution?
- NASA Earthdata. Resolution.
- NASA. What are passive and active sensors?
- Copernicus Sentinel-2 mission documentation.
- ESA Education. Sensors; Passive sensors; Active sensors.

Review these references for deeper study and for examples that connect theory with real Earth observation data.

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