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

Co-funded by the European Union

TIIAME

MICRO-CREDENTIAL

LAND MANAGEMENT IN CENTRAL ASIA

14.- Radar and Laser Remote Sensing

Radar and LiDAR Review

LM-W14-V98

Radar and LiDAR Review

Concepts, interpretation, applications, advantages, limitations, and sensor choice for land management

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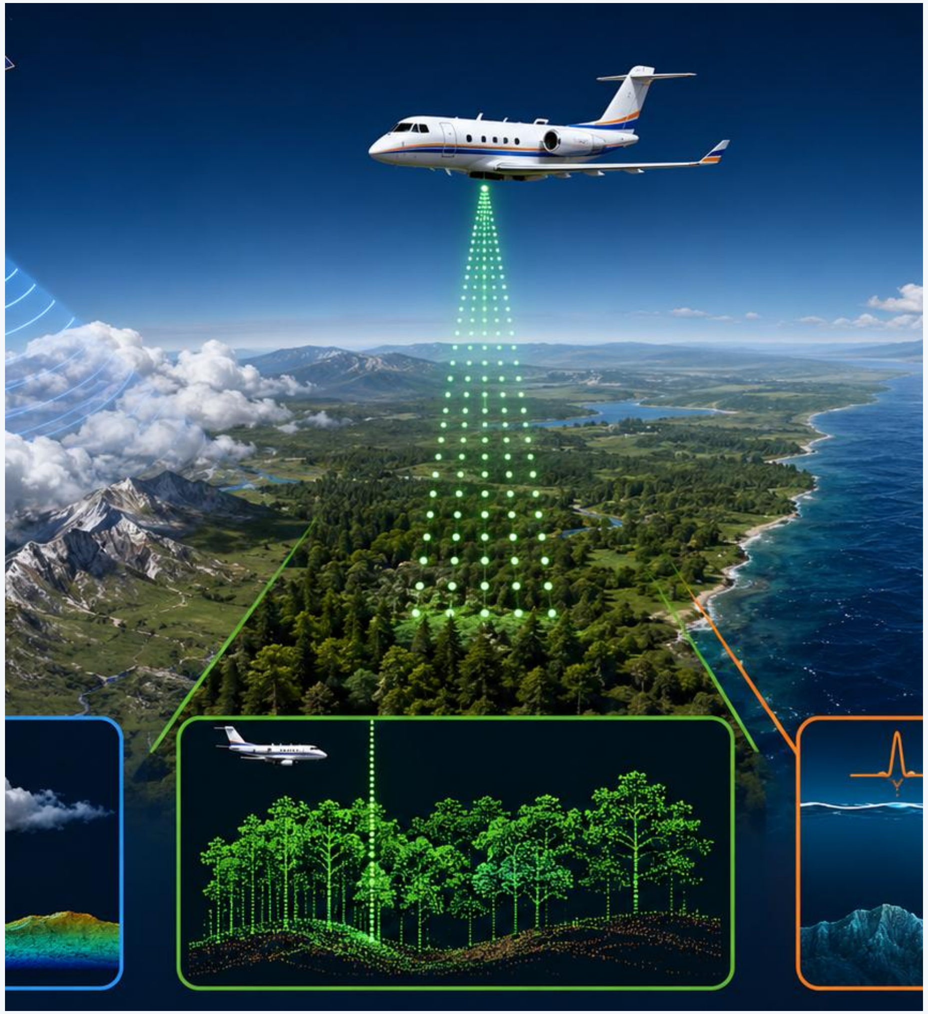
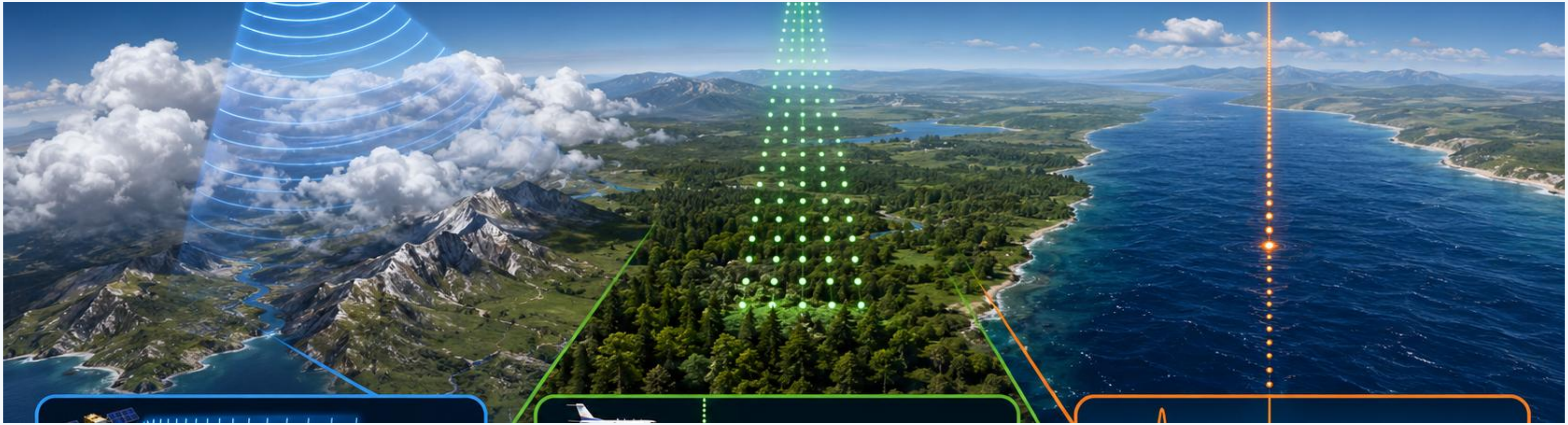
Learning objectives

By the end of this review, students should be able to:

Recall the operating principles of radar and LiDAR systems.
Explain how backscatter, time-of-flight, and point clouds are interpreted.
Compare applications in land, water, terrain, vegetation, and infrastructure studies.
Recognize common limitations, errors, and data-processing needs.
Choose a suitable sensor or integrated workflow for a practical land-management task.



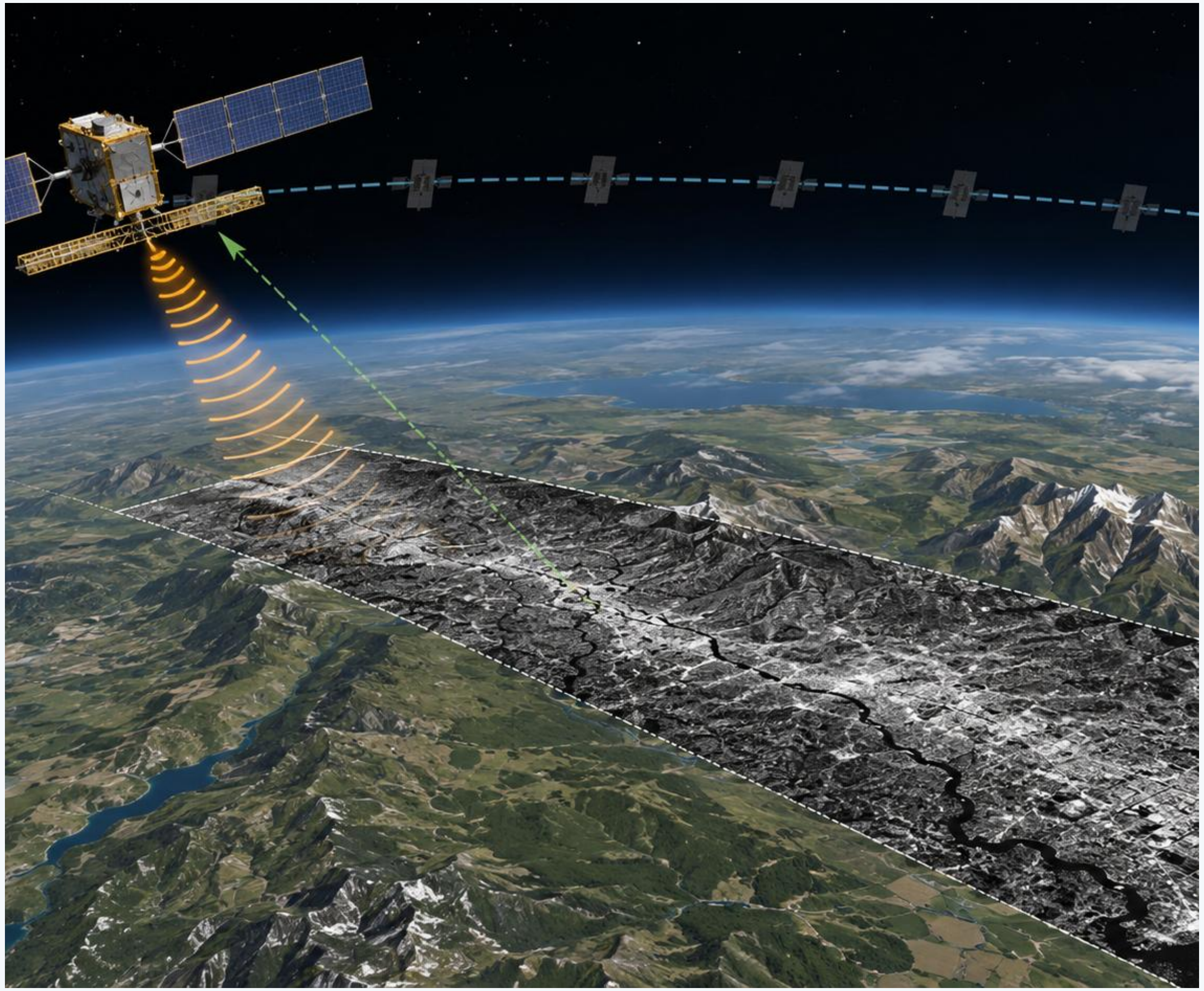
The shared idea: transmit, interact, receive



1. Emit energy → 2. Hit surface → 3. Return signal → 4. Record data → 5. Interpret

Radar and LiDAR are active systems: they do not only “look”; they send energy and measure the returned signal.

Radar review: microwave signal and backscatter

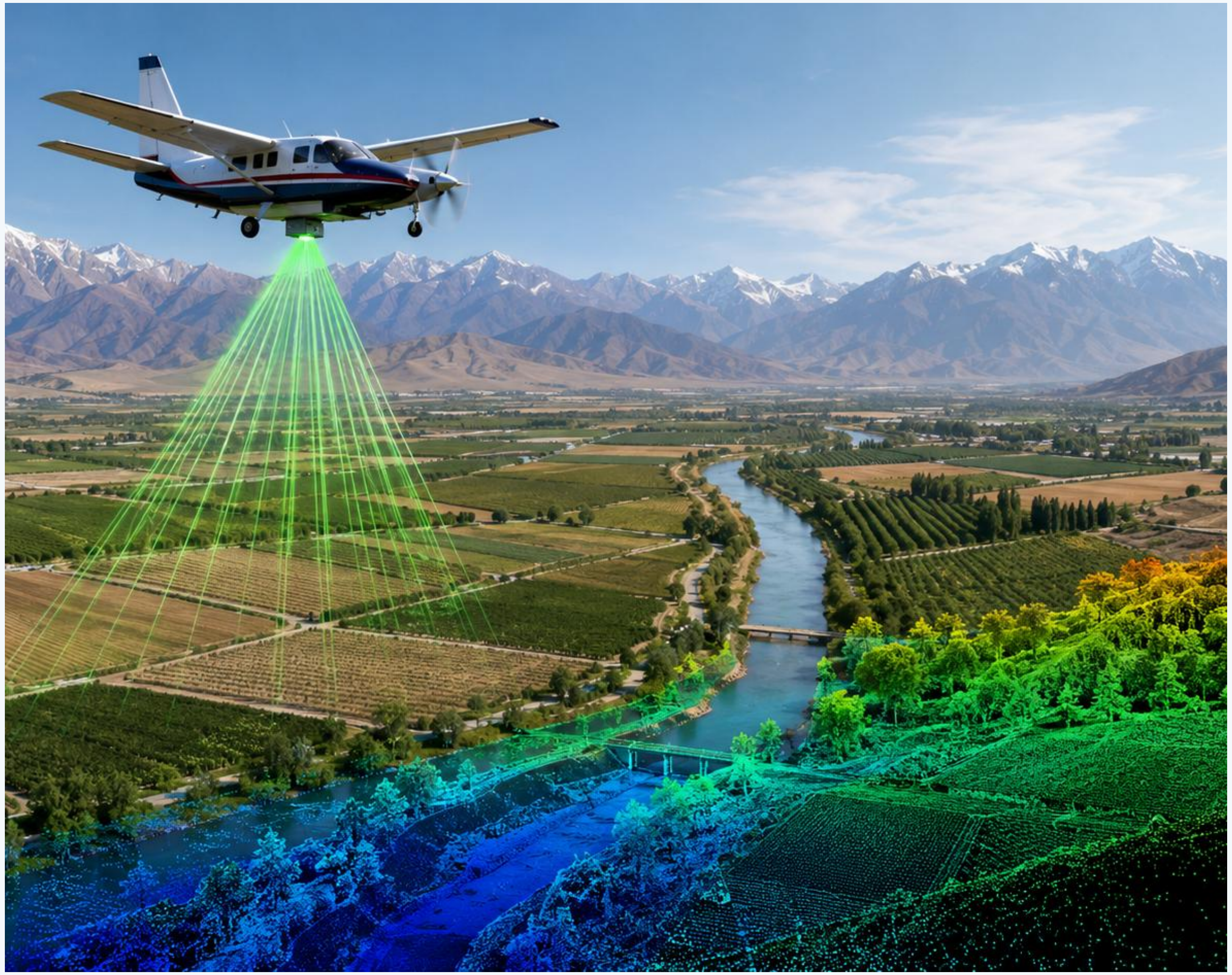


Key interpretation controls

Wavelength: controls penetration and interaction with surface elements.
Polarization: describes orientation of transmitted and received waves.
Incidence angle: affects brightness, shadow, layover, and visibility of slopes.
Backscatter: stronger from rough, moist, or complex structures; weaker from smooth water.

Concept based on NASA Earthdata SAR basics and NASA ARSET SAR training.

LiDAR review: laser ranging and 3D points



Core process

A laser pulse is emitted toward the surface.
Travel time is converted into distance using time-of-flight.
GNSS and IMU record platform position and orientation.
Many measured points form a 3D point cloud.
Classified points support DEM, DSM, canopy and object extraction.

Concept based on NASA GEDI/GEDI LiDAR information and USGS 3DEP materials.

Main products: what do we get from each system?

Radar products

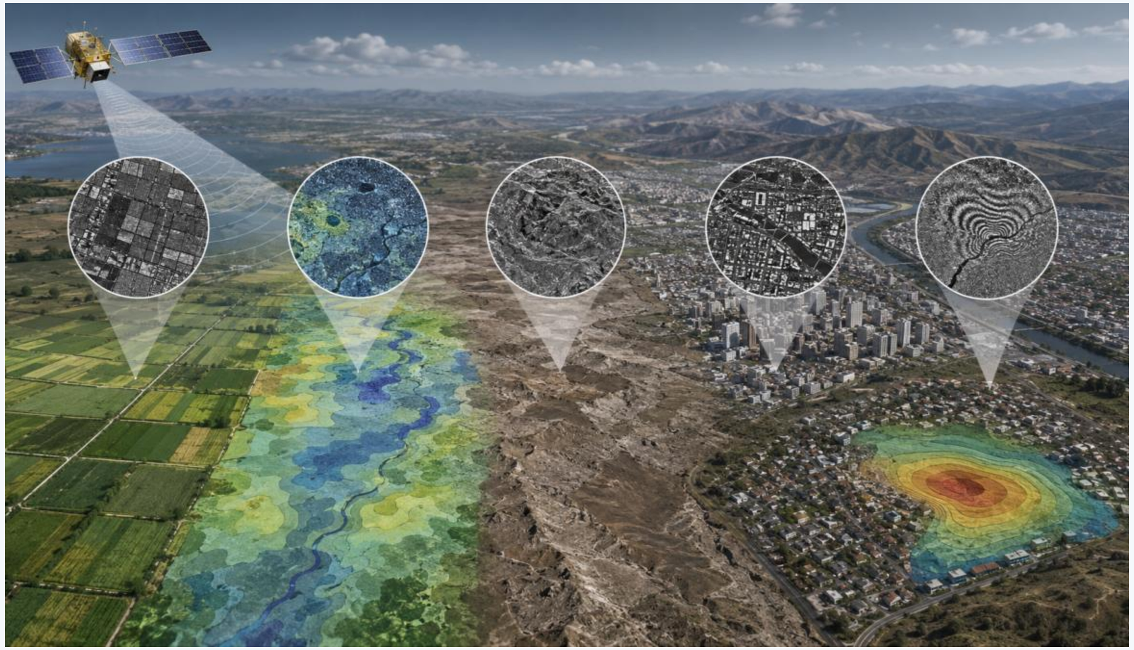
Backscatter intensity images
Multi-polarization composites
Coherence maps
InSAR deformation products
Flood or surface-water masks
Soil moisture and crop structure indicators

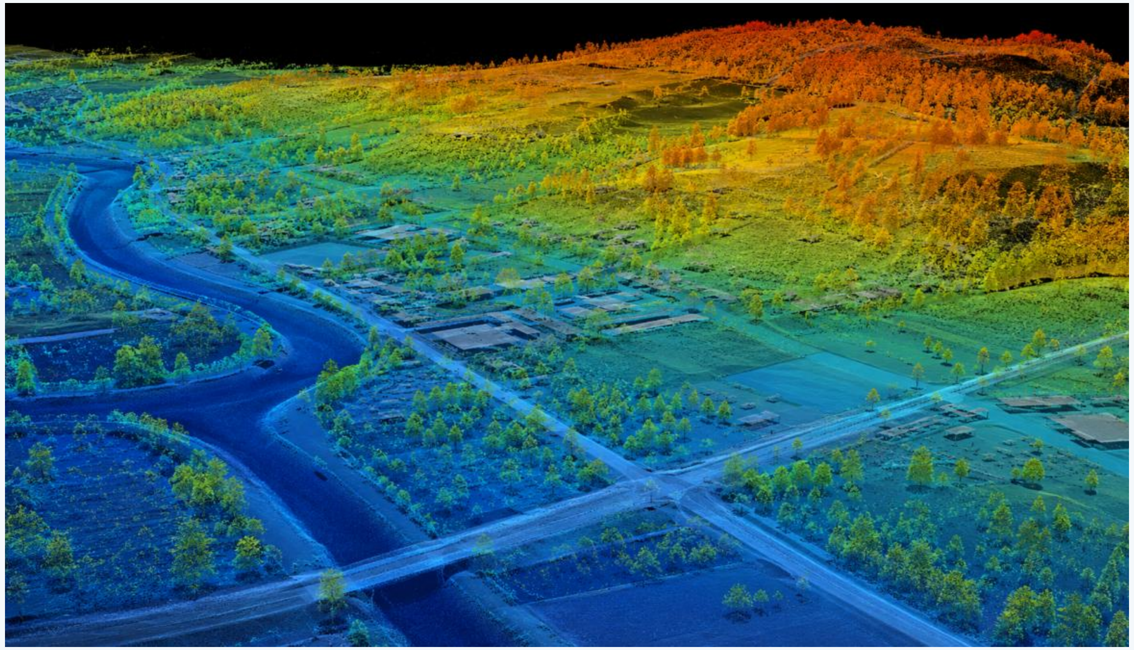
LiDAR products

Raw and classified point clouds
Digital Terrain Models / DEMs
Digital Surface Models / DSMs
Canopy height models
Contours, slope, aspect, hillshade
3D building and infrastructure layers

Review rule: first identify the product you need, then select the sensor.

Visual interpretation clues





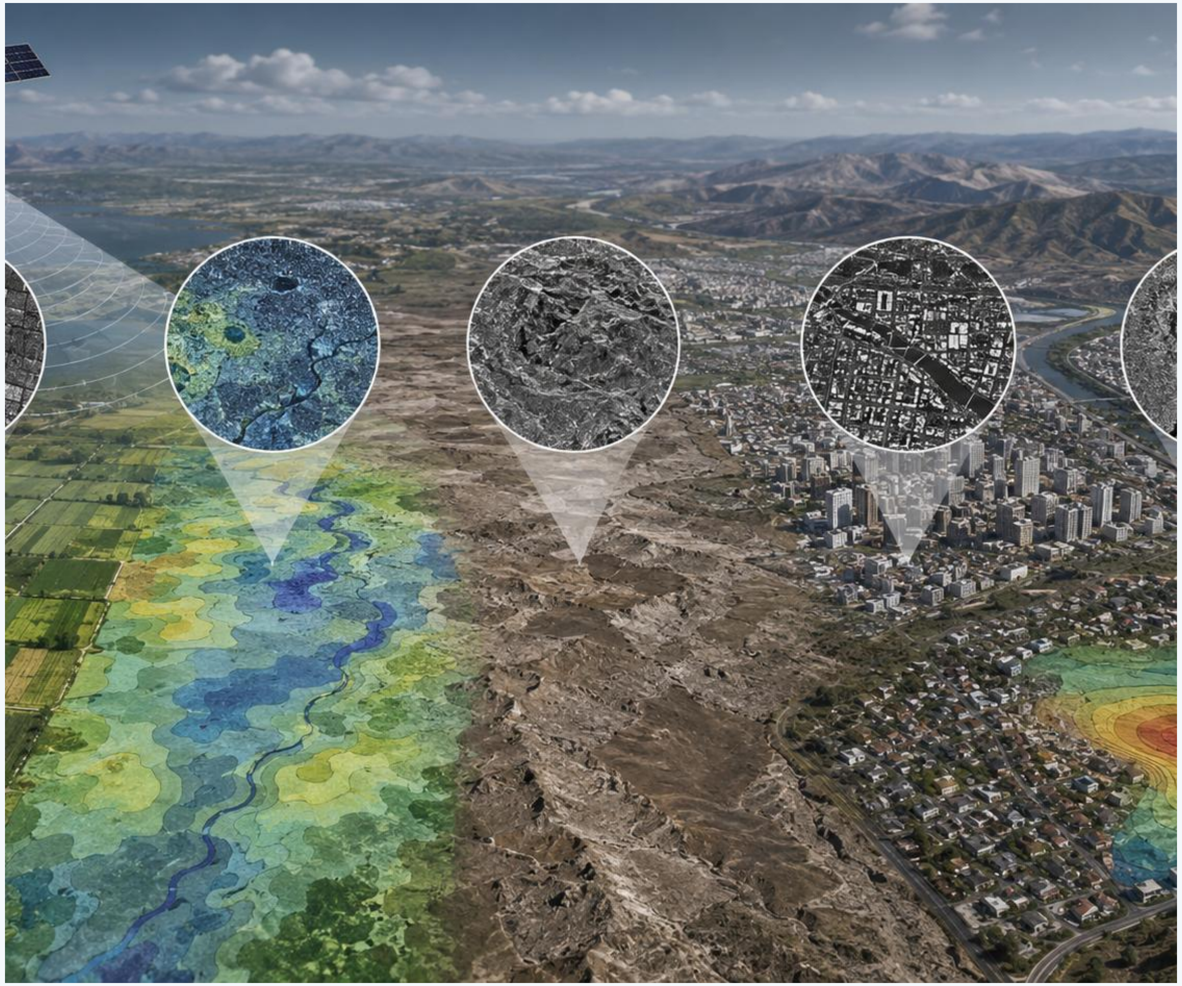
Radar image logic

Bright: strong backscatter from rough, moist or complex targets. Dark: smooth water, radar shadow or low return.

LiDAR image logic

Elevation colour, density, and point class show terrain, vegetation, buildings, embankments and drainage features.

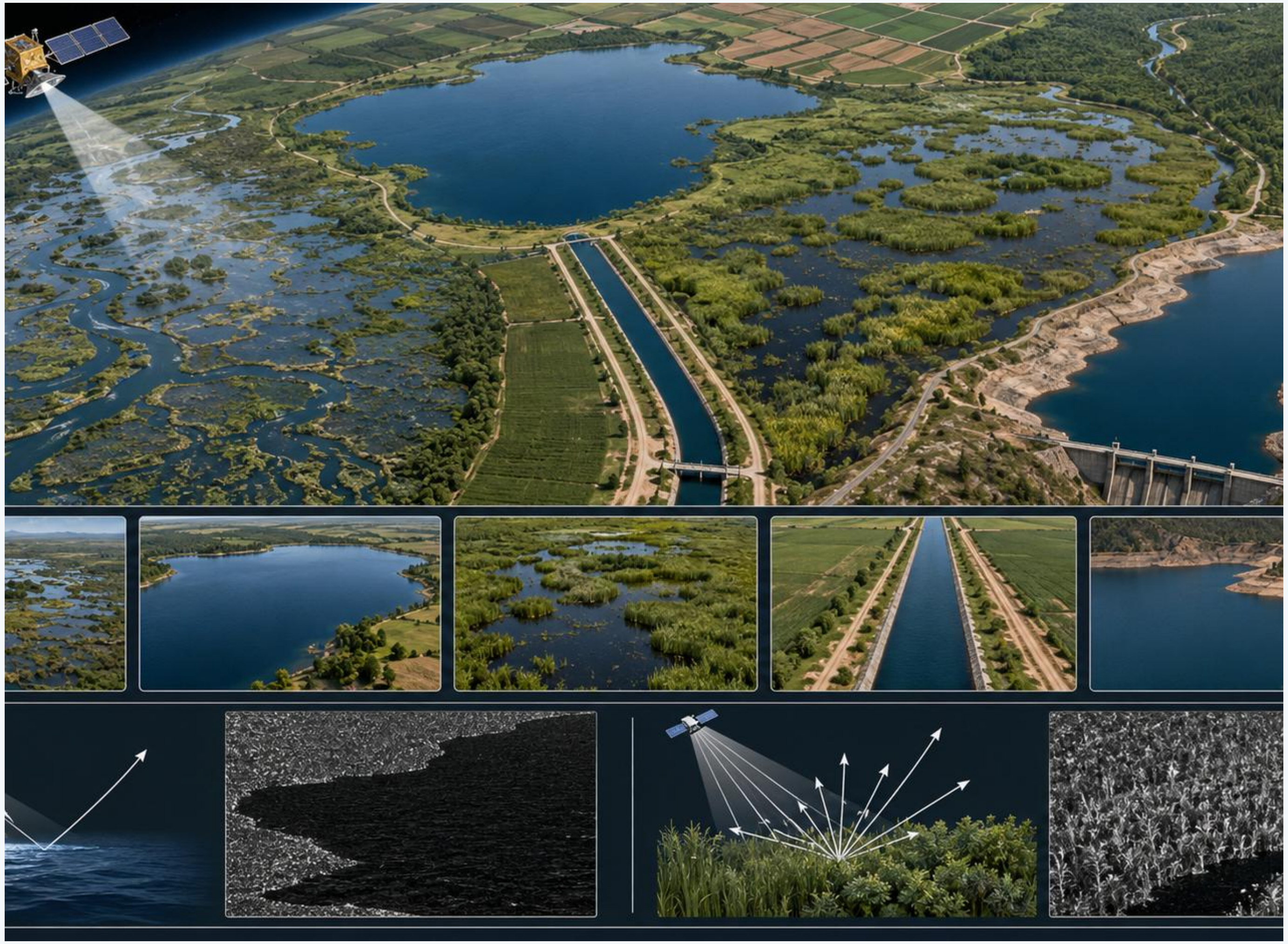
Review of land applications



Agriculture	crop structure, irrigation condition, moisture clues
Land cover	built-up areas, forests, roughness, bare soil
Degradation	erosion-prone surfaces, salinity-prone zones with supporting data
Infrastructure	settlement expansion, linear features, embankments
Terrain	LiDAR slope, aspect, drainage and micro-relief products

In land management, radar and LiDAR are often most useful when integrated with cadastre, field data, land-use maps, and GIS analysis.

Review of water applications



Radar is strong for water extent

Smooth open water often appears dark in SAR images.
Flood mapping can be done even under clouds and at night.
Wetlands may show complex returns from water + vegetation.
Repeated images support seasonal water-change monitoring.

LiDAR supports water engineering

Detailed elevation helps analyze floodplains, canal banks, reservoir margins, drainage paths and embankment condition.

Terrain analysis: LiDAR detail + radar coverage

DEM / DTM

bare-earth surface for mapping and modelling

Slope and aspect

erosion, landslide and irrigation planning

Drainage network

flow paths, depressions and flood routing

Deformation

radar InSAR for subsidence or uplift over time

Advantages: quick comparison

Radar

Works day and night.
Less affected by cloud cover than optical imagery.
Wide-area and frequent monitoring from satellites.
Sensitive to surface moisture, roughness and structure.
InSAR can detect ground deformation.

LiDAR

Very accurate 3D measurement.
Can separate ground, canopy and built structures.
Excellent for terrain models and micro-topography.
Supports engineering, forestry and flood modelling.
Produces dense, intuitive point clouds.

Limitations and common sources of error

Radar

Speckle noise, geometric distortion, complex interpretation, polarization/incidence effects, processing knowledge needed.

LiDAR

Weather limitations, cost, flight permissions, large datasets, point classification errors, limited optical penetration.

Both

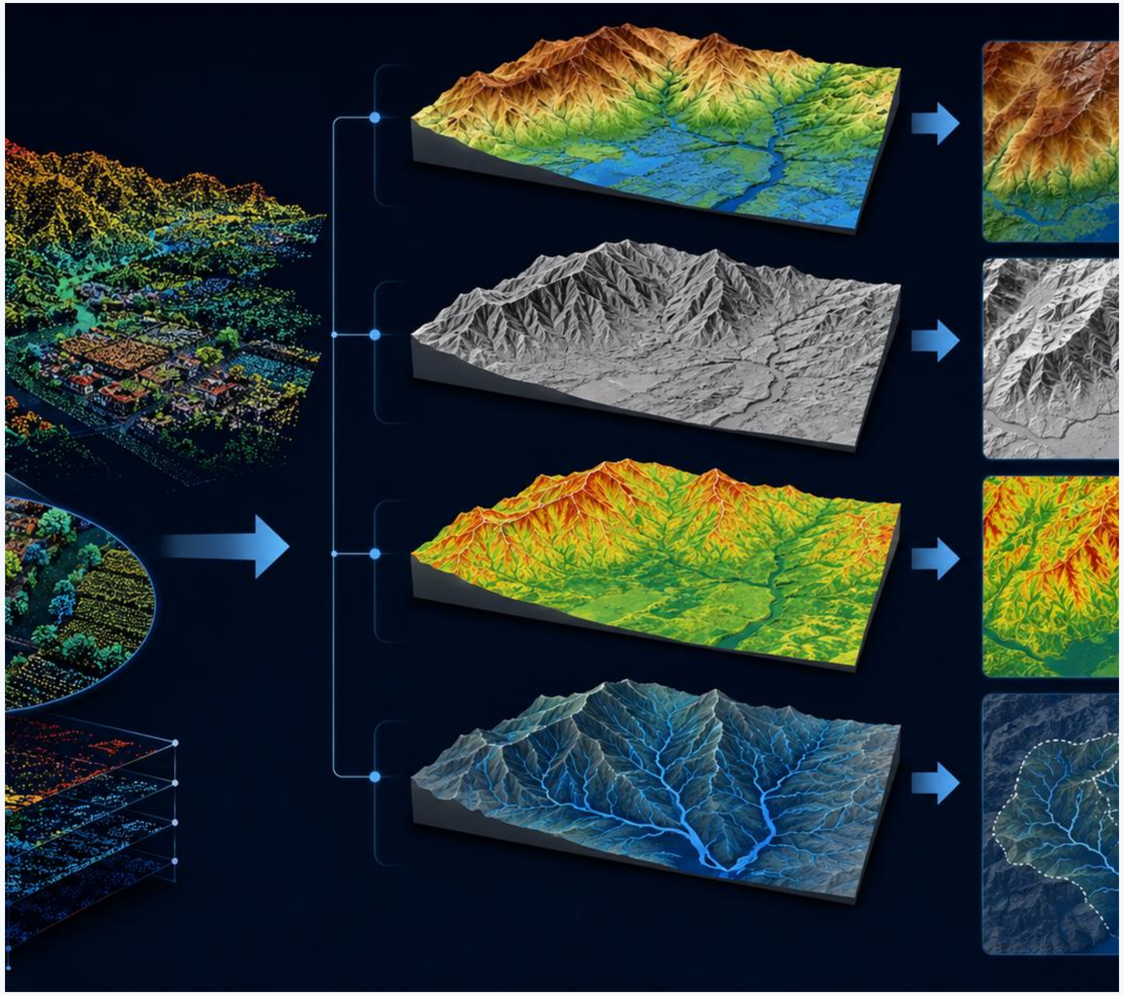
Require calibration, georeferencing, quality control, field validation and clear understanding of scale.

Accuracy is not only a sensor property; it also depends on processing, terrain, atmosphere, validation data and the final application.

Decision guide: which sensor should be selected?

Need	Radar	LiDAR	Best choice	Note
Flood extent under clouds	Excellent	Limited by campaign	Radar	Add DEM
Canal-bank elevation	Indirect	Excellent	LiDAR	Engineering detail
Ground deformation	Excellent with InSAR	Not for frequent wide-area change	Radar	Needs time series
Bare-earth micro-relief	Moderate	Excellent	LiDAR	Point classification
Forest height/structure	Moderate structure clues	Excellent 3D	LiDAR	Radar complements biomass
Large routine monitoring	Strong satellite coverage	Costly if airborne	Radar	Combine with field data

Integrated workflow for land-management analysis



1. Define question	flood risk, salinity, slope, crop monitoring, subsidence
2. Select data	SAR, LiDAR, optical, DEM, cadastre, field observations
3. Pre-process	calibration, terrain correction, classification, filtering
4. Analyze	water masks, slope maps, drainage, change detection, InSAR
5. Validate and decide	field checks, uncertainty, maps for planning or policy

Key review points and references

Summary

Radar and LiDAR are active systems, but they measure different physical responses.
Radar is strongest for all-weather, day-night, repeated monitoring and deformation analysis.
LiDAR is strongest for accurate 3D terrain, vegetation and infrastructure mapping.
Sensor selection must follow the question, scale, budget, terrain, and validation data.
Integrated radar + LiDAR + GIS workflows give stronger evidence for land management.

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