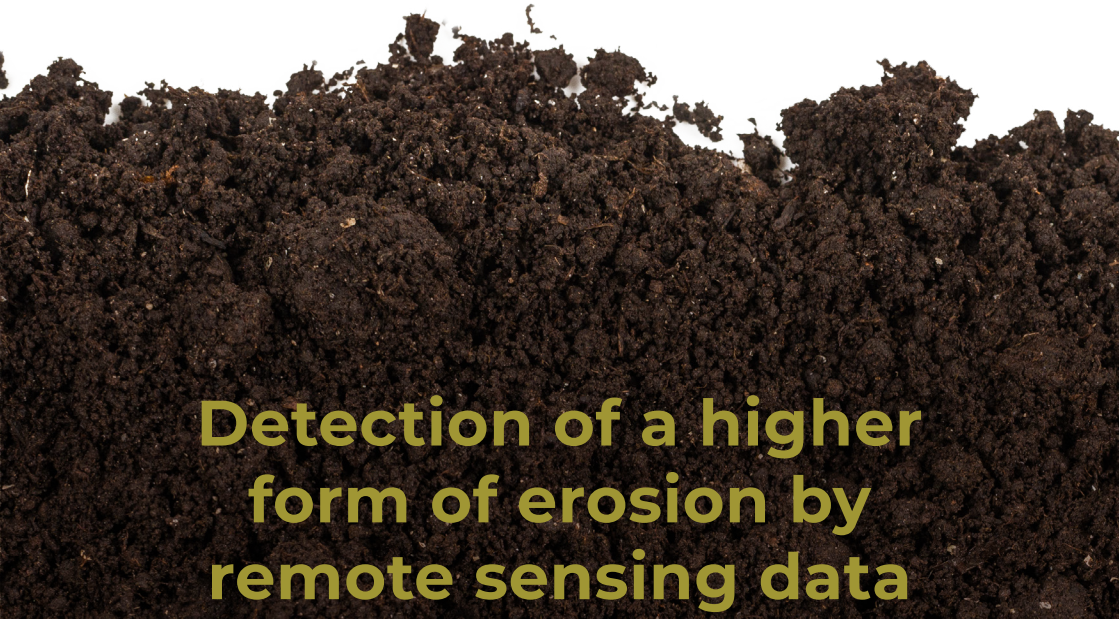
Transforming **U**nsustainable management of soils in key agricultural systems in EU and China

Developing an **i**ntegrated platform of alternatives to reverse soil degradation



Detection of a higher form of erosion by remote sensing data

This project receives funding from the European Union's Horizon 2020 Research and Innovation action under grant agreement No 101000224.

Short description

The detection of higher forms of erosion through remote sensing uses satellite and aerial imagery to identify subtle landscape changes that indicate accelerated erosion processes. By combining spectral signatures with topographic data, remote sensing can identify areas experiencing increased erosion, such as gully formation, soil degradation, or land subsidence. This method offers a non-invasive and efficient way of monitoring large-scale environmental changes. It allows to optimise land management, conservation efforts, and disaster mitigation strategies.

By understanding how erosion occurs in space and time, policymakers and stakeholders can make targeted changes to reduce soil degradation by erosion and encourage sustainable land use.

Target area

This approach is applicable in diverse geographic regions, including areas prone to erosion due to **climatic factors** (e.g., heavy rainfall, wind and drought), **soil characteristics** (erodibility by wind or water), and **specific crop production systems** (e.g., agricultural land, grazing areas). It provides valuable information for managing erosion risks and promoting sustainable land use practices tailored to the local environment. Different remote sensing tools are useful in different

environments depending mainly on scale of assessed erosion phenomena (Mediterranean gullies differ from ephemeral rills and gullies in central and northern Europe).

Problem identification

Detection of erosion through remote sensing reveals challenges in interpreting subtle landscape changes, such as gully formation and soil degradation. It requires accurate data interpretation. **The soil erosion tool in the TUdi DST** (dev-tudi.web.app) serves to identify eroded areas and provide a calibration and verification to remote sensing approaches. This tool offers a straightforward analysis of your land in a few steps, which can help you determine different types of erosion evidences and their intensity.

Detailed description of protection

The integration of publicly available satellite and aerial data sources provides comprehensive coverage for regions around the world, allowing the detection of advanced erosion through remote sensing data. These data sources, including those from organisations like the European Space Agency (ESA), the United States Geological Survey (USGS), and commercial providers such as Planet Labs, are unquestionably the most comprehensive sources of imagery and geospatial information available for monitoring environmental changes.

Growing market for cheap UAV solution allows to use detailed monitoring more efficiently.

Satellite data

Satellite data, such as those obtained from ESA's Copernicus Sentinel series, provide comprehensive coverage of large geographic areas with regular updates. This allows for the continual monitoring of erosion patterns over time. Sentinel-2 captures multispectral imagery every five days at a resolution of 10 metres, which can be analysed to detect changes in land cover associated with erosion processes. Furthermore, radar imagery frafom satellites such as Sentinel-1 can be used for interferometric analysis to identify land subsidence and other deformation phenomena related to erosion, as offered by European Ground Motion Service (EGMS). Great advantage of USGS (Landsat programme) and Copernicus (Sentinel family) is open access. On the other hand their spatial resolutions (10–30m) and temporal resolutions (5–20 days) complicate acquiring cloudless imagery for every erosion occurrence. More advanced commercial satellite systems provide daily availability and higher detail.

Aerial imagery

Aerial data, including those obtained from UAVs, is the perfect complement to satellite imagery. It offers superior spatial resolution, up to centimetres, and the flexibility to collect data in different ways. These datasets provide the most detailed imagery to monitor erosion in smaller areas. They are typically collected independently and in a timely manner by local research institutions or government agencies. Such datasets often comprise RGB imagery, multispectral data, and even LiDAR data, which is essential for creating high-resolution elevation models for terrain analysis.

Accessibility

Many of these remote sensing data sources are openly accessible through data portals and platforms, such as the Copernicus Data Space Ecosystem or the USGS Earth Explorer. This allows researchers, policymakers, and the public to easily access data, which is crucial for collaboration and participation in erosion monitoring and conservation efforts on both local and global scales.

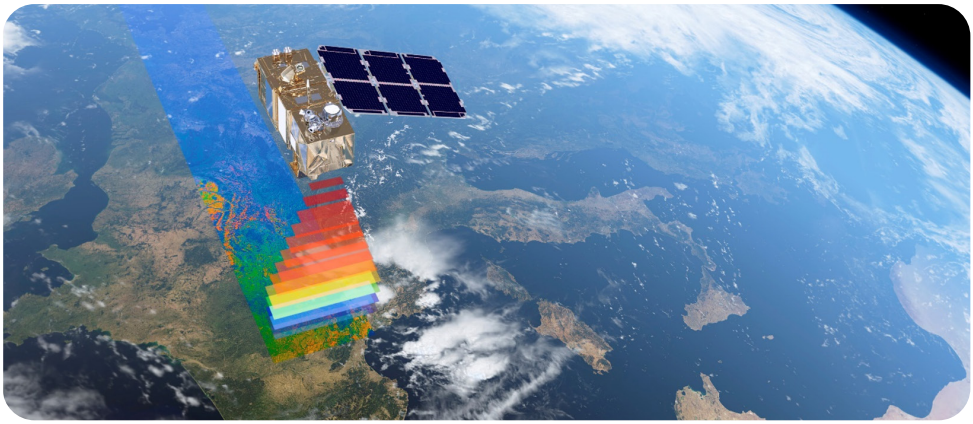


Fig. 1: 'Combining high resolution and novel multispectral capabilities, a swath width of 290 km and frequent revisit times, the new Sentinel-2 mission offers views of Earth's changing lands in unprecedented detail'. Image: ©ESA

Fig. 2: Small, cheap drones can now capture orthophotomap data with centimetre-per-pixel resolution.

An example of public remote sensing data:

- **Copernicus Browser (Copernicus Data Space Ecosystem)** https://browser.dataspace.copernicus.eu/
- **USGS Earth Explorer** https://earthexplorer.usgs.gov/

In conclusion, the integration of publicly available satellite and aerial data improves the effectiveness of erosion detection and monitoring through remote sensing. By leveraging these data sources and advanced analysis techniques, stakeholders can make informed decisions to mitigate erosion impacts and promote sustainable land use practices throughout Europe and the world.

Pros/Cons of technique, obstacles to implementation

Satellite technology offers non-invasive, efficient monitoring over vast land areas, complemented by UAVs' detailed analysis in smaller regions. However, drawbacks include high costs, specialised skills required, and potential data availability issues due to cloud cover. Satellite data may lack temporal resolution for rapid erosion events, and identifying erosion-related features can be challenging. Overcoming technical capacity, integration, funding limitations, and ensuring stakeholder engagement are crucial to successful land management.

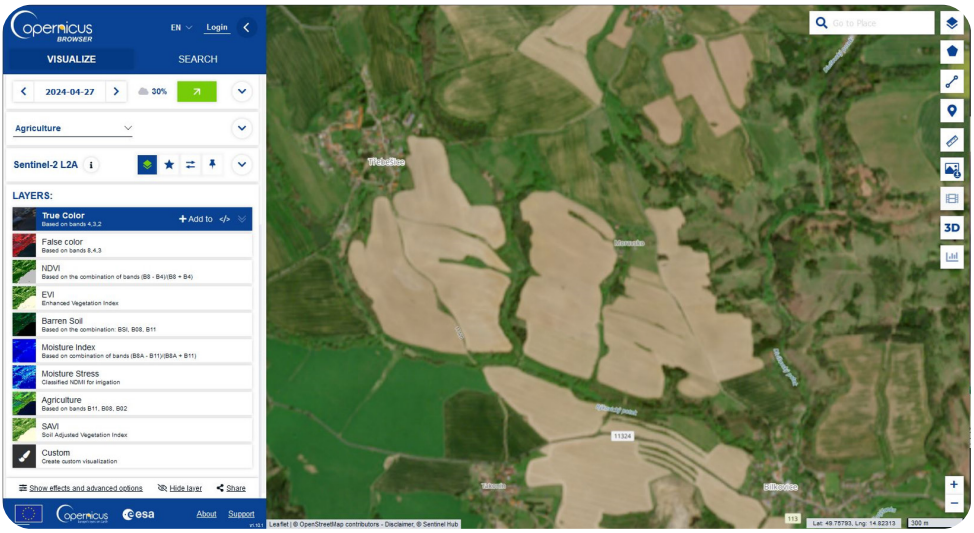


Fig. 3: Copernicus Browser with agriculture thematic data set with pre-prepared data with resulting images in true and false colours and different indices such as NDVI, EVI, etc.

Effects/results/case studies

Enhanced Erosion Monitoring: Remote sensing has transformed erosion detection, providing comprehensive and timely insights into its spatial and temporal patterns.

Targeted intervention: Identifying erosion hotspots enables precise implementation of effective control measures.

Conservation Impact Assessment: Remote sensing is an invaluable tool for evaluating the effectiveness of conservation efforts, including the success of erosion control projects in safeguarding sensitive habitats.

Disaster mitigation: Early identification of erosion-prone areas allows proactive measures to mitigate natural disasters such as landslides or flooding.

Numerous case studies employ satellite imagery for erosion detection, primarily for detecting large-scale erosion. On the contrary, drones, with their high resolution, provide detailed imagery that allows a precise calculation of the volumes of eroded materials using digital terrain models and data analysis.

More literature

In addition to the Copernicus Data Space Ecosystem and the USGS Earth Explorer, there are several other platforms and data portals that provide access to remote sensing data for erosion monitoring and conservation efforts.

- NASA Earthdata: NASA's Earth Observing System Data and Information System (EOSDIS) offers a vast collection of Earth science data, including satellite imagery, aerial observations, and other remote sensing data relevant to erosion monitoring.
- European Space Agency (ESA) Earth Observation Data: ESA provides access to a wide range of satellite data through platforms like the ESA Earth Observation Data Access Portal (EO-SSO) and the ESA Earth Online Portal.

Fig. 4: Comparison of Sentinel-2 true-colour satellite image with 10 m/pixel resolution and orthophoto map taken by UAV with 2.8 cm/pixel resolution with visible erosion furrows, which can also be used for more detailed analysis, e.g. calculation of eroded material.

- Global Foresta Watch (GFW): GFW offers a variety of forest remote sensing data sets, including satellite imagery and LiDAR data, which can be useful for monitoring erosion in forested areas.
- National Oceanic and Atmospheric Administration (NOAA) Data Access: NOAA provides access to satellite data, aerial imagery, and other environmental data through platforms such as the NOAA Data Catalogue and the NOAA Environmental Data Management System (EDMS).
- Maxar Open Data Programme: Maxar offers access to satellite imagery through its Open Data Programme, providing high-resolution imagery that can be used for erosion monitoring and analysis.
- Google Earth provide valuable source of hi-res archive imagery for initial analysis of land-use and land degradation in specific regions without need for advanced GIS skills.

These platforms, among others, offer valuable resources for accessing remote sensing data and supporting erosion monitoring and conservation efforts on both local and global scales.

Summary

The use of remote sensing represents a highly valuable tool for the detection of advanced erosion. It uses satellite and aerial data to identify subtle landscape changes, indicating accelerated erosion processes such as gully formation and land subsidence. It offers non-invasive, efficient monitoring, aiding land management, and disaster mitigation globally. However, there are challenges, including cost, technical complexity, and interpretation issues. The integration of publicly available data improves accuracy, but obstacles such as limited access and stakeholder participation persist. However, the positive outcomes of the targeted interventions and improved land management are clear. The Loess Plateau case study is a clear example of remote sensing's effectiveness.

Summary table

	Rating	Comments
Soil health overall	***	
Water budget	**	
Soil structure	*	
Erosivity	***	
Nutrient balance	**	
Soil life	*	
Practicability	**	
Economy	**	

Consortium

Agrisat; Beijing Forestry University; Beijing Normal University; Centre for Agricultural Research; China Agricultural University; Czech Technical University in Prague; Lincoln University; New Bulgarian University; Northwest A&F University; Northwest UNIVERSITY; Pensoft Publishers; Spanish National Research Council; University of Lancaster; BOKU University, Vienna; University of Turin; Federal Agency for Water Management, Austria

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