Satellite Agriculture Service

Welcome. In this video, we explore a practical example of how satellite data and geospatial intelligence can support modern agriculture, transforming raw observations into operational knowledge. We often think of agriculture as something that happens only at field level, through tractors, irrigation systems and direct human intervention. However, modern agriculture increasingly relies on large-scale observation systems, capable of continuously monitoring crops, soil conditions, environmental stress and climatic behaviour. This is exactly the philosophy of the Agriculture service: rather than treating a field as something to be inspected only from the ground, it treats the agricultural territory as a living system whose condition can be measured, mapped and followed over time.

To illustrate this, we will follow a comprehensive agricultural risk and resilience analysis generated over a complete Area of Interest, often abbreviated as AOI. Within this area, more than one hundred thousand individual spatial cells are processed, each one carrying information about vegetation, water, soil, heat and atmospheric conditions. The result is not a single map, but a layered portrait of the agricultural landscape. In the following sections, we will look at what this service examines, which satellite data it relies on, what kind of results it produces, and finally how all of this information is visualized and explored within the EagleArca platform. And one idea will return throughout: vegetation health, biomass, moisture, heat, drought, flood risk, terrain deformation, erosion and atmospheric conditions are not independent phenomena. They interact continuously, and their real value emerges only when they are read together.

What the Service Examines

The Agriculture service is built around the idea that a crop behaves like an environmental sensor. Plants respond to water, temperature, nutrients and stress, and these responses can be observed from space before they become visible on the ground. Rather than focusing on a single variable, the service examines the agricultural environment across several complementary dimensions, because agricultural risk never depends on one factor alone.

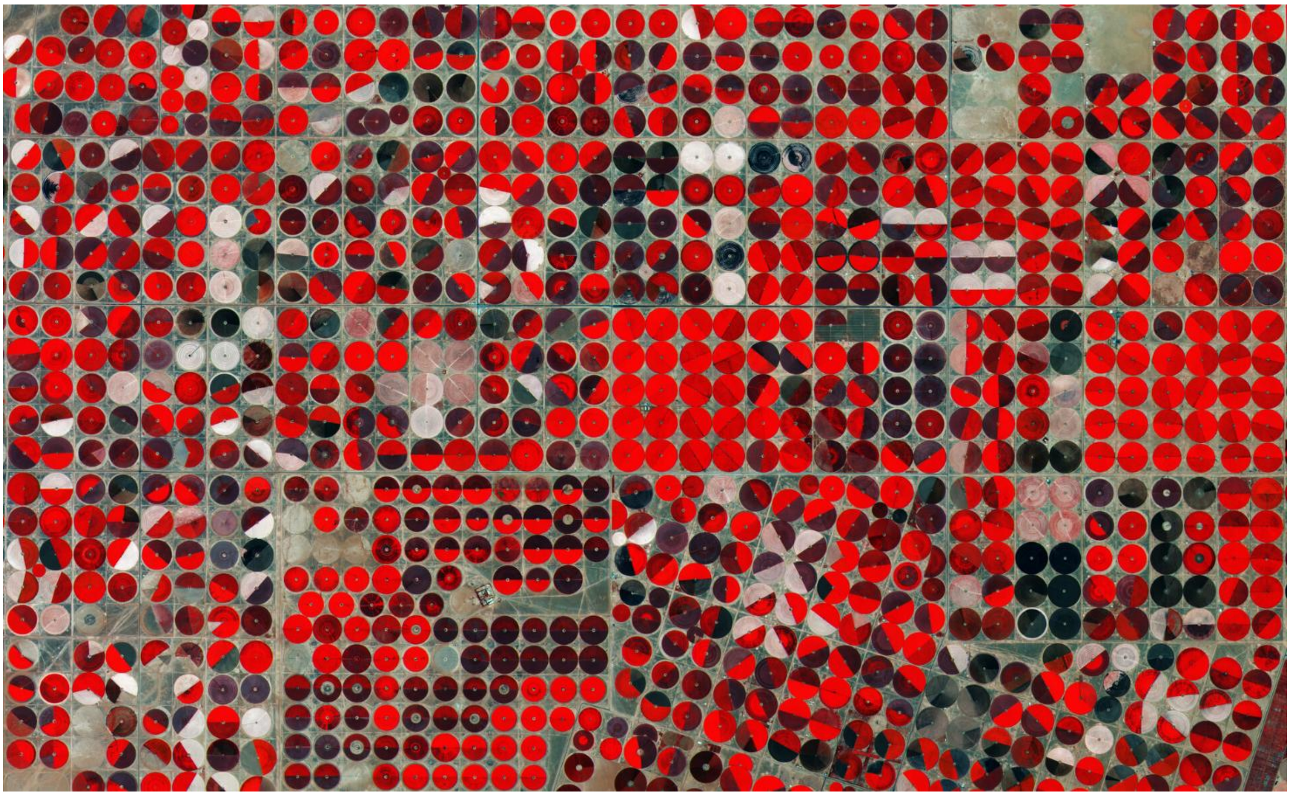
The first dimension is the health and vigour of the vegetation itself: how actively the crops are growing, and where they are showing signs of stress. Closely related is the amount of vegetation present, the biomass, which acts as a direct proxy for crop productivity and development. The second dimension is water. The service examines how much moisture is present in the soil, where fields are too dry and may require irrigation, and where they are persistently too wet and may suffer from drainage problems. It also looks at how efficiently water is actually used, not simply whether it is present.

The third dimension is hydrological risk within the farmland: the susceptibility of agricultural land to flooding and the identification of drainage convergence zones, because excessive water accumulation can be just as harmful to crops as drought. The fourth dimension is the stability of the terrain. Agricultural systems depend on stable ground for their irrigation infrastructure, canals, access roads and drainage systems, all of which can be affected by slow ground movement. The service therefore examines vertical ground deformation across the agricultural landscape.

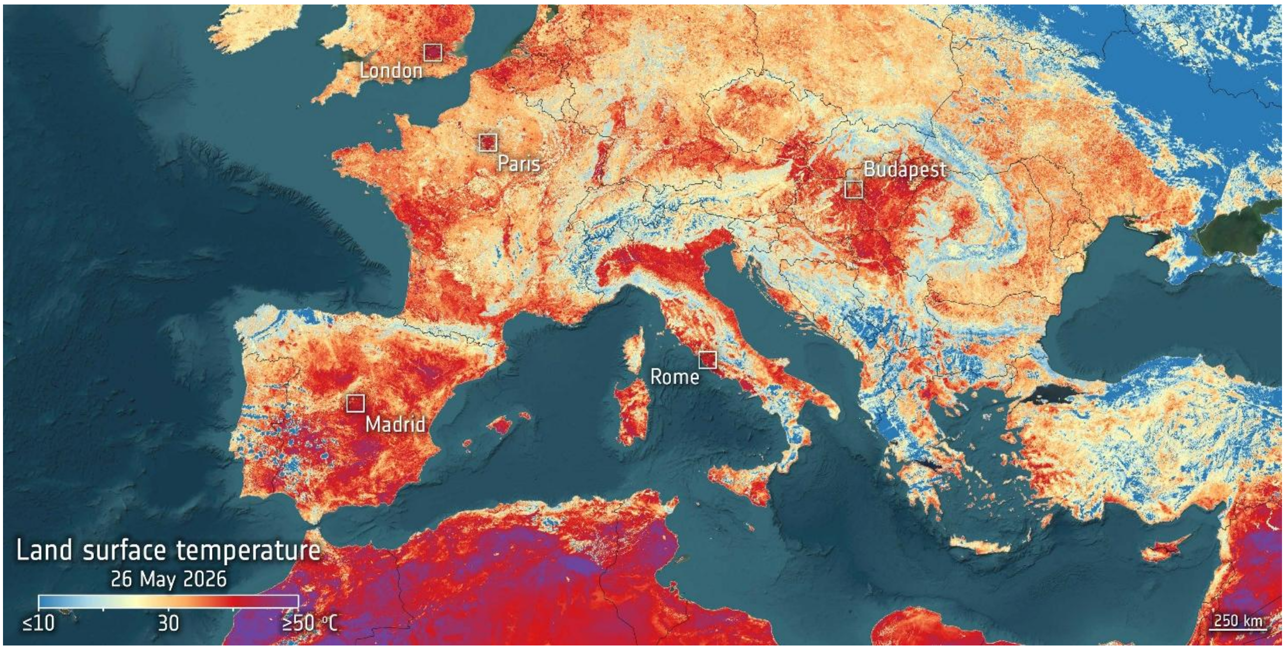
The fifth dimension is the long-term sustainability of the soil, through the assessment of erosion susceptibility, since productive topsoil develops over centuries but can be lost rapidly. The sixth dimension is thermal and climatic stress: how often crops are exposed to heat conditions that exceed their optimal range, and how drought develops progressively through the interaction of several environmental signals. Finally, the service examines the pressure that atmospheric pollution places on crops, because air quality and agricultural productivity, once considered separate domains, are in fact deeply interconnected. Taken together, these dimensions describe not just what is growing, but how the agricultural system is performing and where it is fragile.

What Data the Service Uses

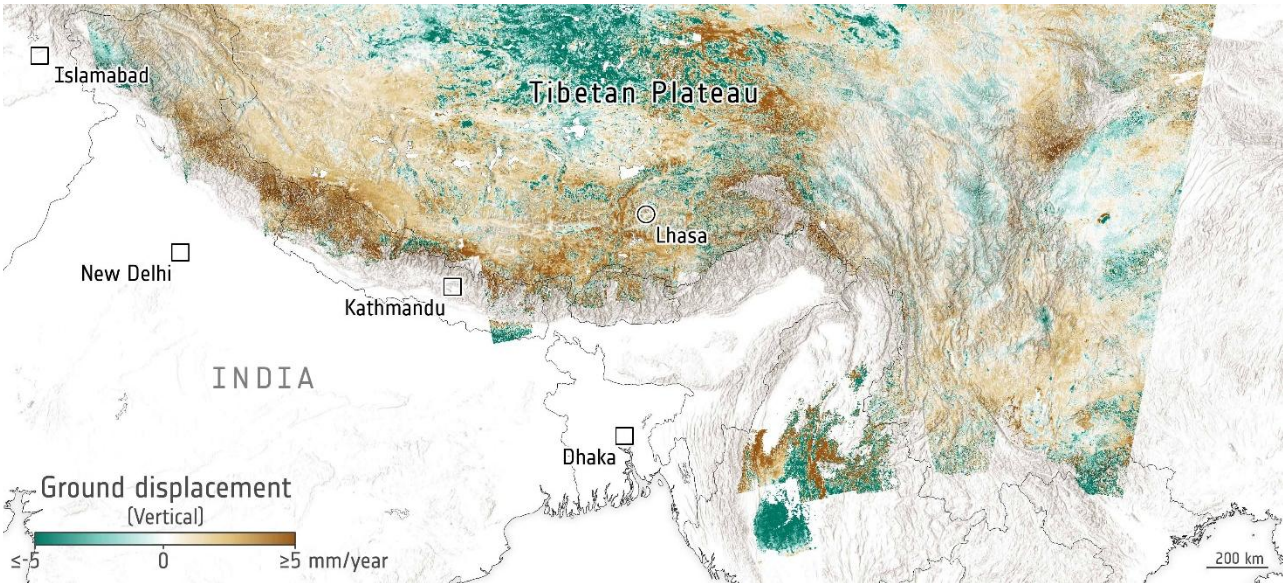
To examine these many dimensions, the Agriculture service does not rely on a single satellite. It integrates observations from several missions of the European Union's Copernicus programme, each contributing a different and complementary physical measurement. This is fundamental, because no single sensor can capture the full complexity of an agricultural system. Optical reflectance, thermal emission, radar backscatter and atmospheric chemistry all describe different physical aspects of the same territory, and the real power lies in fusing them.



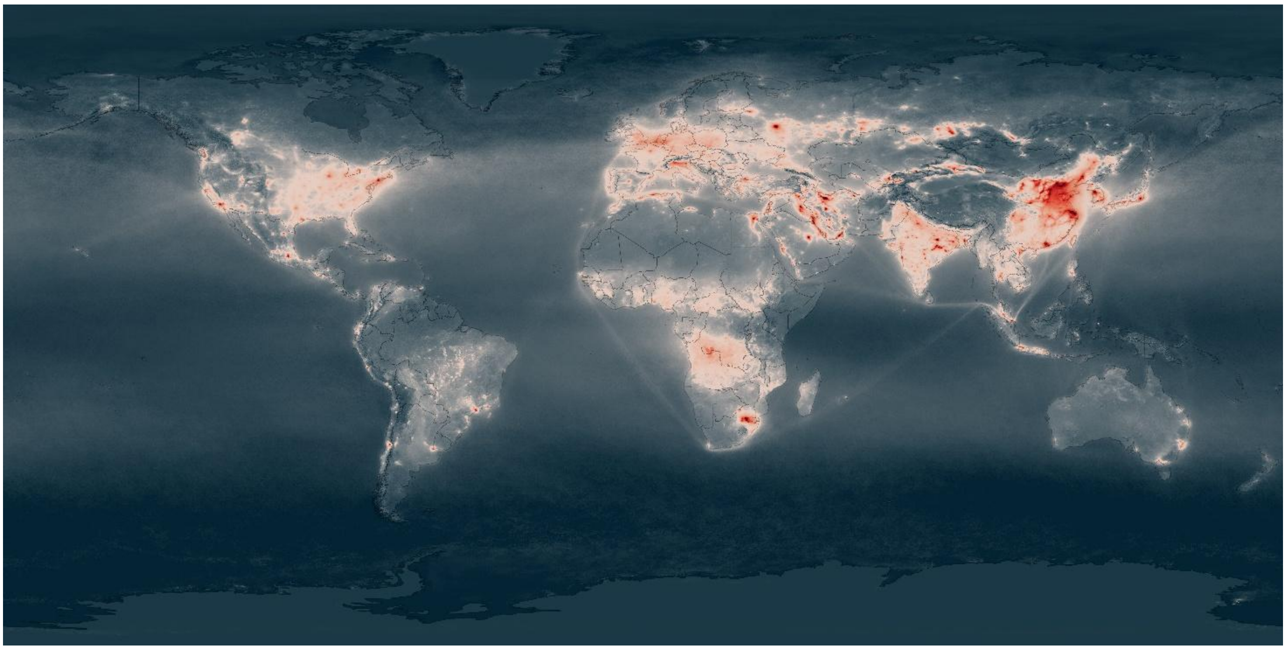
The first and most central source is **Sentinel-2**, the optical multispectral mission. Sentinel-2 measures how the surface reflects solar radiation across thirteen spectral bands, from the visible to the short-wave infrared. This is the foundation of crop monitoring, because vegetation has a very characteristic spectral behaviour: healthy plants absorb strongly in the red band, due to chlorophyll, and reflect strongly in the near-infrared, due to the internal structure of their leaves. By combining these bands, the service derives vegetation indices that describe crop vigour and stress, it estimates biomass, and it follows how these change through the growing season. Because Sentinel-2 captures subtle physiological changes before visible symptoms appear, it acts as an early-warning instrument for crop health.



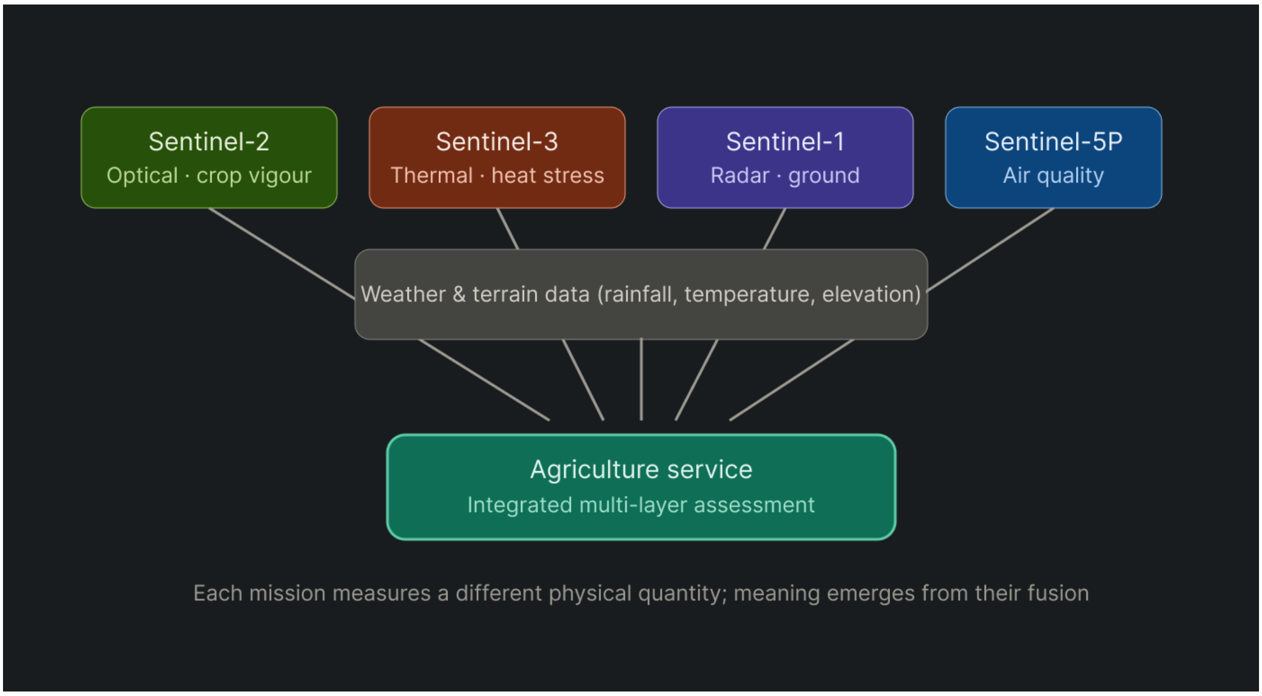
The second source is **Sentinel-3**, and in particular its thermal observation capability. Sentinel-3 measures the radiation that surfaces themselves emit, which makes it possible to estimate Land Surface Temperature. In agriculture, this is what allows the service to assess crop heat stress, identifying how frequently and how intensely crops are exposed to temperatures beyond their optimal physiological range.



The third source is **Sentinel-1**, the radar mission. Because radar is an active sensor that emits its own microwave signal, Sentinel-1 observes the surface regardless of cloud cover or daylight. Through interferometry, which compares radar acquisitions over time, it detects ground movement at the scale of millimetres. This is what allows the service to monitor land subsidence across agricultural areas and to identify risk zones for irrigation canals and infrastructure. Radar is also sensitive to surface roughness and soil moisture, adding further information about field conditions.



The fourth source is **Sentinel-5P**, the atmospheric monitoring mission. Its TROPOMI instrument measures the concentration of pollutants and gases in the atmosphere. In the agricultural context, this provides the basis for assessing how atmospheric pollution pressure may compound crop stress and affect yield.

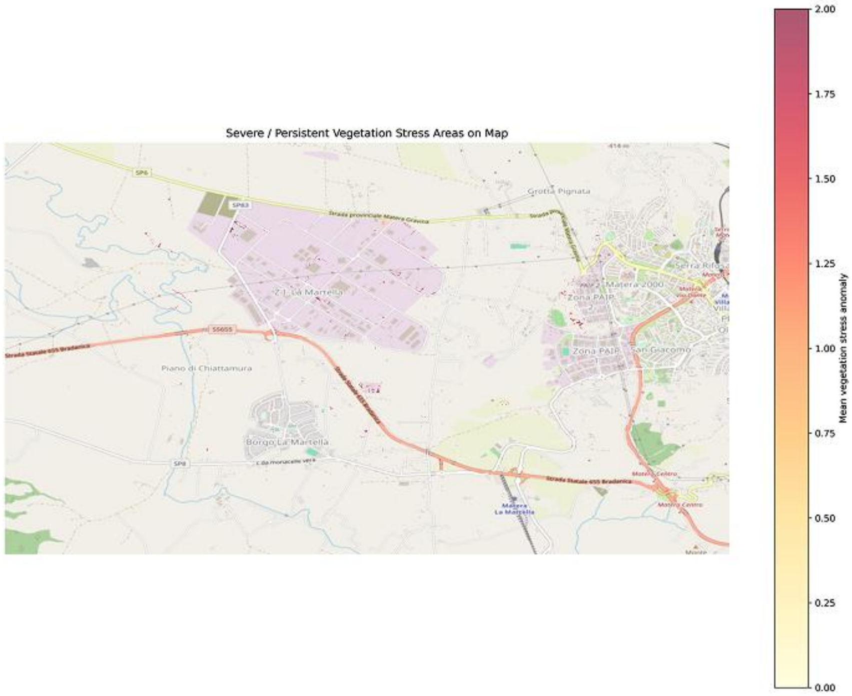


Finally, the service integrates meteorological and climatic information, such as rainfall and temperature, together with terrain data. This context is essential for drought monitoring and for the hydrological and erosion components, where the shape of the land and the behaviour of precipitation combine with crop and soil conditions to determine risk. The strength of the service lies precisely in this integration. Each mission measures a different physical quantity, and only by combining them does a complete picture of the agricultural system emerge.

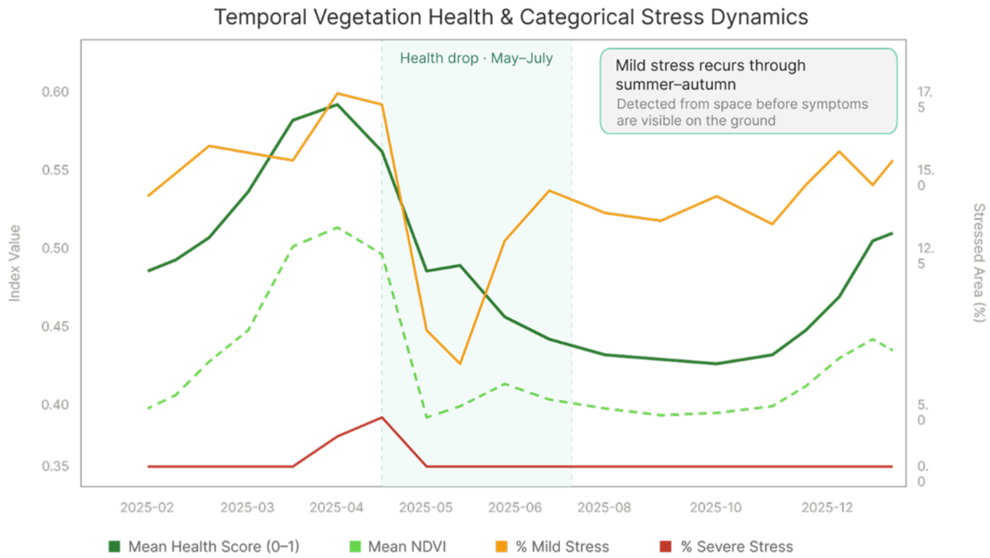
Applied Results

Once these data sources are combined and processed, the service produces a structured set of indicators that describe the state of the agricultural environment and its exposure to risk. Let us walk through them in a logical order, and at each step look not only at what is measured, but at why it matters.

Vegetation Health



The analysis starts with one of the most fundamental indicators in precision agriculture: vegetation health. Satellite systems continuously monitor the spectral response of vegetation and transform reflectance values into indicators that describe crop vigour and stress. In this report, the average vegetation health index reaches approximately 0.52, while stress anomaly values indicate recurring stress conditions in specific locations across the observed territory. Vegetation health monitoring is one of the most powerful applications of optical satellite imagery, precisely because plants behave like environmental sensors. Healthy vegetation reflects radiation differently from stressed vegetation, so through multispectral acquisitions satellites can observe subtle physiological changes before visible symptoms appear on the ground.

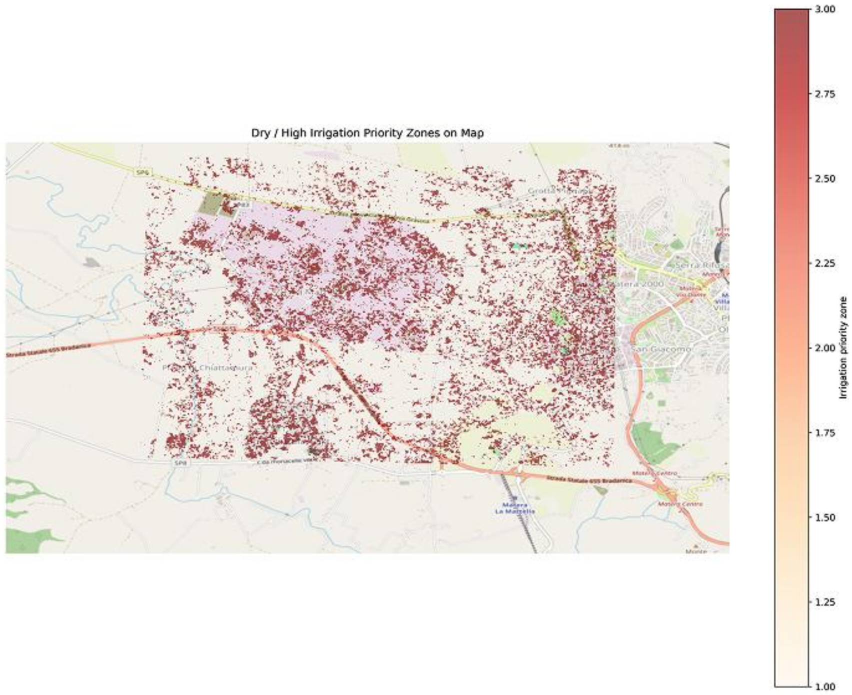


One of the most interesting aspects is the temporal evolution of vegetation behaviour. Rather than providing a static snapshot, the analysis follows crop conditions through multiple acquisition periods, illustrating the fluctuations in vegetation vigour and stress dynamics across the entire year. This temporal perspective is essential, because agricultural systems are dynamic biological processes. A single measurement rarely provides enough information; it is the trends over time that reveal crop cycles, the accumulation of stress, seasonal behaviour and possible anomalies that may require field inspection.

Biomass

The analysis then moves towards biomass estimation. Biomass represents one of the most direct indicators of crop productivity and plant development. Average biomass values indicate the amount of above-ground vegetation present within the observed area, and areas with lower biomass become immediately visible through geospatial mapping. Biomass estimation is particularly valuable because it acts as a proxy for agricultural productivity. Areas showing reduced biomass may indicate nutrient deficiencies, water limitations, disease effects or developmental delays. A temporal accumulation curve further highlights seasonal growth behaviour and reveals how vegetation responds throughout the year.

Soil Moisture



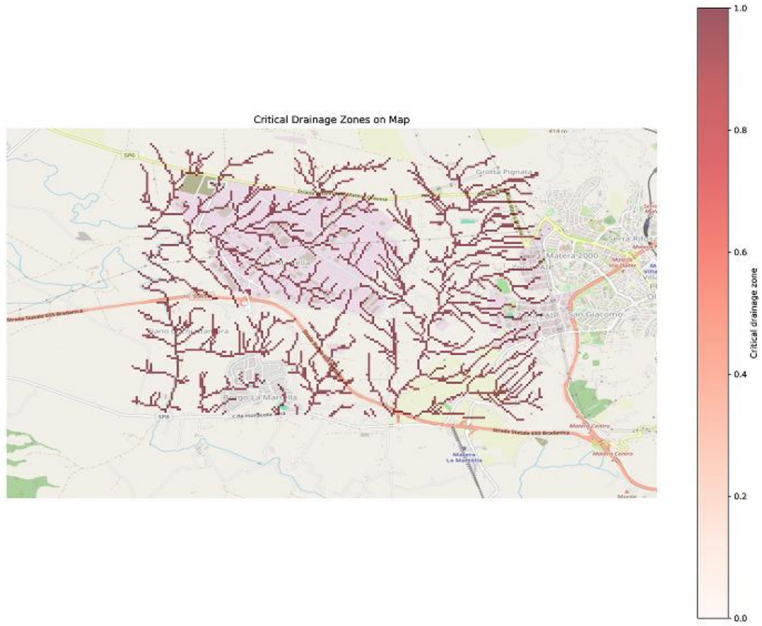
Agricultural management strongly depends on water availability, which leads to the next analytical layer: soil moisture monitoring. The analysis estimates moisture conditions across more than one hundred thousand cells and identifies irrigation optimization zones, where intervention priorities may exist. Soil moisture is one of the most critical variables in agricultural systems, because it controls plant water uptake, nutrient transport, microbial activity and overall crop development. Both excessive dryness and excessive wetness can negatively affect productivity. What makes this analysis particularly useful is that moisture information is transformed into actionable recommendations: dry zones requiring higher irrigation priority become immediately identifiable on maps, while persistent wet zones can instead reveal drainage issues that require attention.

Irrigation Efficiency

Indicator	Valid cells	Mean	Range
Irrigation anomaly zones	121542	0.032	0.000 – 0.395
Water productivity index	114135	0.023	-0.004 – 0.052

The analysis then extends irrigation assessment through efficiency metrics. Irrigation anomaly indicators and a water productivity index attempt to understand not simply whether water is present, but whether it is used effectively. This distinction is important, because sustainable agriculture is not only about increasing water availability; it is about optimizing the use of the resource. Water productivity combines crop response with water input efficiency, supporting precision agriculture practices that reduce waste.

Drainage and Flood Risk



The analysis then shifts towards hydrological risk, through drainage and flood susceptibility assessment in farmland. Agricultural flood risk and critical drainage zones are estimated spatially across the entire territory. Flood susceptibility in agricultural environments is often underestimated. While irrigation shortages receive considerable attention, excessive water accumulation can be equally harmful: saturated soils reduce the oxygen available to roots, damage crop development and increase susceptibility to disease. By identifying drainage convergence zones, satellite analysis can support preventative interventions.

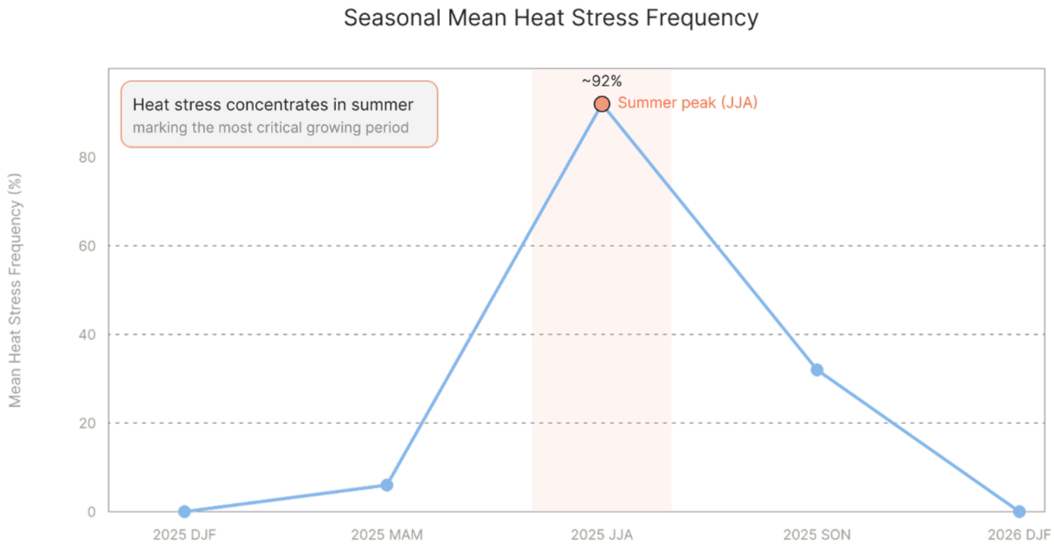
Land Subsidence

The analysis then introduces land subsidence monitoring. Ground displacement measurements, derived from satellite radar interferometry, provide information about vertical movement behaviour across the agricultural landscape, and risk zones for infrastructure and irrigation canals are additionally identified. This may initially appear more relevant to urban environments, but agricultural systems strongly depend on stable terrain. Irrigation infrastructure, water channels, access roads and drainage systems can all be affected by subtle ground deformation. Monitoring displacement at the scale of millimetres allows the early identification of potential infrastructure problems before they become serious.

Soil Erosion

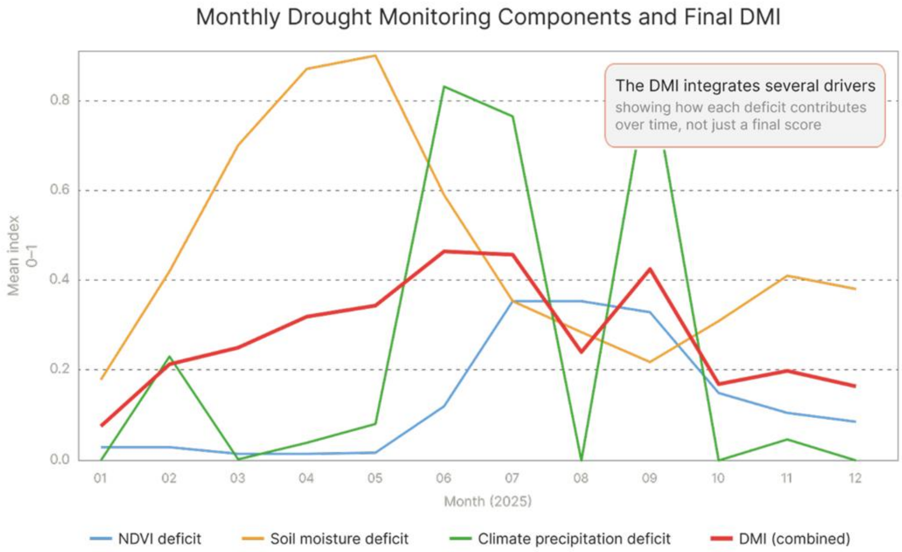
The analysis continues with soil erosion. Erosion susceptibility classes categorize areas according to their vulnerability, while priority intervention zones identify regions that may require mitigation actions. Soil erosion represents one of the greatest long-term threats to agricultural sustainability. Productive topsoil develops over centuries, but it can disappear rapidly due to runoff processes, inappropriate land management and climatic extremes. Understanding where erosion risk accumulates enables targeted conservation measures.

Crop Heat Stress



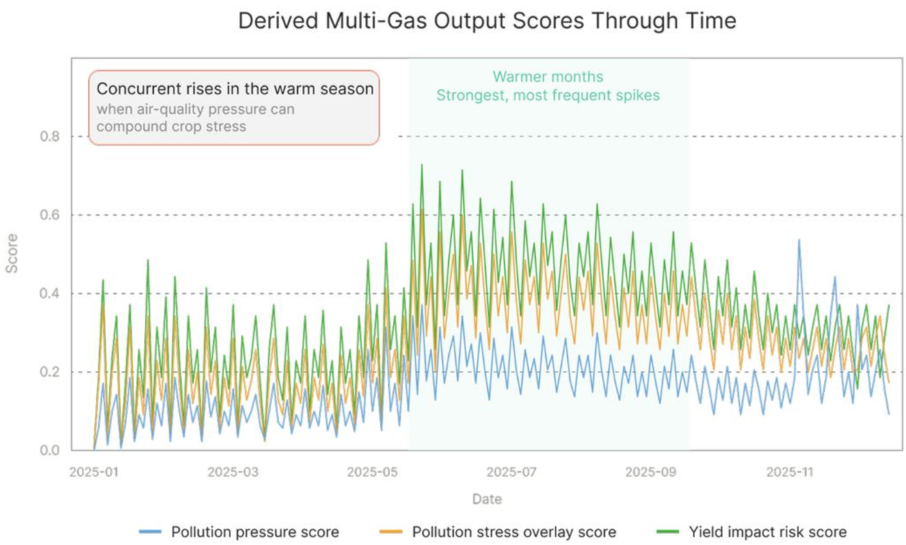
The next indicator focuses on crop heat stress. Satellite-derived temperature observations identify the frequency and intensity of heat conditions that may affect crops, and vulnerability classifications reveal which areas experience stronger thermal pressure. Heat stress is becoming increasingly important under changing climatic conditions. Plants have optimal physiological temperature ranges, and when temperature exceeds critical thresholds, the efficiency of photosynthesis decreases, transpiration patterns change and productivity declines. The seasonal analysis shows the periods characterized by stronger heat-stress frequency, allowing the identification of the most critical growing periods.

Drought Monitoring



Closely connected to heat is drought monitoring. The analysis integrates multiple environmental signals into a drought severity index, capable of identifying early-warning conditions. Drought rarely emerges suddenly. It develops progressively, through the interaction between precipitation deficits, rising temperatures, moisture depletion and vegetation response. By integrating multiple indicators, satellite systems can provide early signals before severe agricultural impacts become visible. A particularly useful aspect is the temporal decomposition of the drought drivers: rather than delivering only a final severity score, the system analyses how the different components contribute over time.

Multi-Gas Crop Risk



Finally, the analysis introduces an innovative concept: multi-gas crop risk assessment. Here, atmospheric pollution pressure is integrated with vegetation stress analysis to estimate possible effects on agricultural productivity. Traditionally, agriculture and atmospheric quality were considered independent domains. Modern Earth observation demonstrates that these systems are deeply interconnected. Pollutants such as ozone, nitrogen compounds and other atmospheric contaminants can amplify crop stress and reduce yield performance. Bringing this dimension into the analysis closes the loop, connecting what happens in the atmosphere to what happens in the field.

Visualization in EagleArca

What makes this kind of analysis remarkable is not any single indicator on its own. The true value emerges through the integration of all these dimensions into a unified analytical framework. Vegetation health, biomass, moisture, heat stress, drought, flood risk, terrain deformation, erosion and atmospheric conditions interact continuously, and only together do they describe how the agricultural system truly behaves. This represents the evolution of satellite-based agriculture. Instead of isolated measurements, Earth observation systems increasingly provide holistic environmental intelligence. Satellite platforms are no longer simply imaging systems; they have become analytical infrastructures, capable of describing biological, hydrological, thermal and atmospheric dynamics simultaneously. When these indicators are integrated inside a GIS-based platform such as EagleArca, they become operational tools rather than isolated results.

In EagleArca, each of the indicators we have discussed corresponds to a geospatial layer that can be visualized on the map. Because all layers share the same coordinate system and are georeferenced within the same spatial framework, they can be overlaid and compared directly. This is what turns separate measurements into genuine understanding. An area showing reduced vegetation vigour can be examined alongside the soil moisture layer to see whether the cause is a water deficit. A zone of elevated heat-stress frequency can be read together with the drought index to confirm a developing water-stress condition. A field flagged for low biomass can be overlaid with the erosion or subsidence layers to understand whether terrain factors are involved. In each case, the meaning comes from the relationship between layers.

From an operational perspective, users can spatially compare crop conditions, identify anomalies, monitor their evolution through time, and support agricultural decisions with objective data. Layers can be activated and deactivated, specific areas of interest can be examined in detail, and indicators can be followed over time, distinguishing normal seasonal cycles from genuine anomalies. Ultimately, this demonstrates how satellite systems move beyond simple observation and become decision-support infrastructures, capable of improving resilience, sustainability and precision within modern agricultural ecosystems. By transforming raw observations into actionable knowledge, the Agriculture service helps farmers and managers not only understand the current condition of their land, but also anticipate future risks and plan accordingly.