How Can Space Make a Difference for the Agriculture Sector

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Introduction

The Land component of Copernicus program is requested to address the needs of several EU Policy areas relevant to the Regional dimension such as: Climate change, Land degradation and desertification, Forest resources, Biodiversity, Water resources, Agriculture, Rural development and Food security. Referring to the three latter ones, the largest community of the sector is represented by EIP-AGRI. The European Innovation Partnerships (EIPs) are a relatively new approach to EU research and innovation. They are challenge-driven, focusing on societal benefits and a rapid modernization of the associated sectors and markets. EIPs are launched in areas in which government intervention is clearly justified and where combining EU, national and regional efforts in research and development and demand-side measures will attempt to achieve the goals in a quicker and more efficient manner. There are five established EIPs, focused on the following areas: *Active & Healthy Ageing; Agricultural Sustainability and Productivity; Smart Cities and Communities; Water; Raw materials.*

The aim of this document was to provide an informative study that illustrates concrete examples and effective solutions based on space technologies that are already in place across European Regions in the domain of Agriculture and Rural Development. Agriculture sector seems to be particularly suitable for the development of the new markets where larger industries but also small and micro enterprises using Remote Sensing technologies could address local and individual needs of farmers and cultivators with new, innovative and efficient user- targeted services. For these purposes, the information coming from the new generation of Sentinel satellites, in particular Sentinel-1 and Sentinel-2, and their integration into existing systems could have an important role and could stimulate the creation of new and innovative applications, services and products for a better organisation of agricultural production, rural development and territorial management in general.

The concept of agriculture production

The concept of ***agriculture production*** is used in the field of economics in reference to the type of products and benefits generated by activities of Agriculture. Agriculture or the cultivation of grains, cereals and vegetables, is one of the principal and most important activities for the livelihood of human beings, which is why its products are always a relevant part of the economies of the majority of regions worldwide, regardless of how advanced its technology or how high its profitability may be. The concept of Agriculture usually also includes important activities such as livestock, together with all of its branches, such as the production of meat and dairy products and their by-products, canned or processed foods (cold cuts, greases, gels, etc.) or manufactured products such as butter, cheeses, creams, etc. and even hides and products for cosmetics, health and many other applications.

Agribusiness is the combination of agriculture, livestock and all of their applications and by-products. This is generally globally referred to as ***"agriculture production"*** as it is based on primary production in one form or another. "Agriculture product" and "Agriculture production levels" are terms often referred to by the European Commission (EC) in the main document regarding this industry branch i.e. Common Agriculture Policy (CAP, see Appendix II).

European Innovation Partnerships (EIP) on Agriculture

In 2012 the European Commission has launched the ***European Innovation Partnership for Agricultural productivity and Sustainability (EIP-AGRI).*** This initiative aims to foster a competitive and sustainable agriculture and forestry sector that "***achieves more from less***". It contributes to ensuring a steady supply of food, feed and biomaterials, and to the sustainable management of the essential natural resources on which farming and forestry depend, working in harmony with the environment. To achieve this aim, the EIP-AGRI brings together innovation actors (farmers, advisors, researchers, universities, businesses, NGOs, public sector etc.) and helps to build bridges between research and practice.

Agriculture is one of the sectors majorly subsidized by European funds on national, regional and local level, with the aim to foster a more productive and sustainable development. Due to a large territorial scale at which agricultural phenomena are observed, and thus the spatial resolution required, it is also one of the main sectors that has been monitored from space over the past 30 years, supported by numerous applications, projects and specifically developed services.

Recent efforts of NEREUS regions to propose an establishment of a new, transversally useful EIP on Space have encountered relevant interest among all EIPs and specifically EIP-AGRI that was one of the communities most interested about innovative space-based applications. In particular, agricultural monitoring, for both end-users and policy making purposes, poses requirements in spatial and temporal resolution that can be met by the new generation of satellites' sensors. Furthermore, Agriculture sector seem particularly suitable for the development of the new market where even small and micro enterprises using Remote Sensing technologies can successfully address local and individual needs of farmers and cultivators. The following sections explore on specific issues that could make a difference for the agriculture sector.

How could Space Technologies make a difference for the agriculture sector?

An increasing number of Satellite imagery that is and will be available in the next years, with a substantial contribution of European Copernicus initiative, are envisaged to stimulate a large number of innovative services and products for a continuous and more systematic monitoring of Agricultural activities. The unprecedented combination of temporal and spatial resolutions of new Sentinel data , together with previous initiatives, will offer new opportunities for innovative solutions responding to specific user needs in the Agriculture sector.

The growing initiatives towards a more efficient data collection, archiving and sharing based on spatial data infrastructures will allow the required integration with the other available geospatial data coming from in situ observations or more active participation of citizens. Hence international initiatives like Global Forest Observation Initiative – GFOI (http://www.gfoi.org/about-gfoi/) and Global Agricultural Monitoring, GLAM (http://earthobservations.com/geoglam_grs.php) conducted by GEO (Group for Earth Observation) or the European Directive INSPIRE regarding the geospatial data in general, can favour the interoperability of systems and a better exchange of information in order to support informed decision-making in an increasingly complex and environmentally stressed world.

This section illustrates some parameters relevant to the Agriculture sector and possible applications of satellite remote sensing technologies.

Biophysical Parameters

The estimation of biophysical parameters, such as **Leaf Area Index (LAI)** and **fraction of Absorbed Photosynthetic Active Radiation (fAPAR)**, from remotely sensed data represents a challenging and important topic. The information on spatial and temporal distribution of these parameters plays a central role in ecosystem and agriculture monitoring. In particular LAI describes the amount of plant leaf material in a vegetated surface. This variable plays a key role in crop modelling with respect to the simulation of processes, such as photosynthesis, respiration, evapo-transpiration and rain interception. Therefore, attention must be given to the direct **use of these LAI products for crop modelling**. It is important to remind that the direct validation of current satellite products has been performed over a small number of reference sites typically close to producers. Although these sites provide a globally representative sampling across land cover (grassland, cropland, different forest types, etc.), these sites do not include all types of crops. In fact, the available agricultural sites comprise typically a mixture of land cover types over a 3x3 km area. Since accuracy of global

LAI datasets at regional scale is often poor or not available, their use can limit the provision of detailed information on specific areas for downstream application. Improvement of this moderate resolution LAI products can be achieved by downscaling time series to disaggregate the product coarse resolution using the information about their pixel composition provided by HR data. SAR data may provide also an appropriate alternative to optical data retrieving LAI, as well as other crop structural parameters. Given the availability of regularly acquired multi-temporal Sentinel-1 dual polarization data and detailed in situ data, existing electromagnetic scattering models (ESM), particularly, the cloud model will be evaluated, ***in primis***, for the inference of key crop bio-physical parameters enabling the estimation of the crop conditions along the whole crop season.

Possible applications

Since the launch of LANDSAT-1 in 1972, Earth Observation (EO) technology has been used extensively in agricultural systems for **crop identification and area estimation, crop yield estimation and prediction, and crop damage assessment**. Dedicated data processing provides a characterisation of the cultivated land in qualitative (crop typology and within-field spatial variability) and quantitative (timing of crop stages, biophysical parameters, such as LAI) terms.

Crop models: such models have been increasingly used since the 70s to analyse the interactions between plants and factors driving their growth as weather, soil, and management practices. At the beginning, the studies were mainly focused to formalize the knowledge on different physiological processes into integrated systems. This led to very detailed models and drew attention to gaps in understanding. Starting from the mid-80s, crop modellers focused their researches to develop ***management-oriented models*** suitable for ***field decision-making***. In the last years, the technological developments supported the large-scale application of crop models. In this context, one key use is the application of **models for monitoring crops conditions and forecasting yields**, at regional, national and international scales. In some of the available crop monitoring systems (e.g. MARS - Monitoring Agricultural ResourceS system of the JRC-EC), the information produced by modelling and those derived by the analysis of satellite images are used asynchronously, by a statistical post-processing of the two different types of information. In other cases, modelled data and those derived by EO are used in a more integrated way by: forcing some of the state variables simulated by crop models using EO derived information, by carrying out re-calibrations of crop parameters or by deriving spatially-distributed sowing dates instead of using fixed sowing calendars.

The characterisation of cultivated land in qualitative and quantitative terms was fundamental for crop modelling, since it includes spatial information on the crop status. Meteorological variables, needed by crop model for their simulation, can be also retrieved from satellite data. These spatially distributed estimates can complement, or substitute, the traditional data source provided by automatic weather stations or, for large-scale applications, by meteorological models.

Generally speaking in EO, crop detection and crop/soil variability identification fall into the pattern recognition field: different targets can be identified and extracted from the images only if they have a different spectral, polarimetric or temporal behaviour. Since crops can exclusively be differentiated by their leaf biochemical and canopy morphological characteristics, and these may have a similar response – in spectral, polarimetric or temporal terms – the synergetic use of different sensors (e.g. SAR and optical) and techniques is a key requirement.

Soil properties: Synthetic Aperture Radar (SAR) systems show a specific sensitivity to important soil properties, such as roughness and moisture content. These properties and their evolution over time are not casual as far as agricultural surfaces are concerned. Good results have been obtained from multi-temporal SAR data by applying conventional supervised classifications. The constraint of this approach is that the data must be acquired with the same geometry and regularly along the whole crop season. With the present missions, key issue is the unavailability of SAR sensors with a suitable repeated cycle (for instance ENVISAT ASAR has a repeated cycle of 35 days): for this reason the integration with other SAR and/or Optical sensors is a pre-requisite for the provision of accurate crop maps. The launch of Sentinel-1A (12 days repeat cycle), Sentinel-1B (6 days in combination with 1A) will solve both problems: the geometric and temporal one.

Soil-Plant interaction: The agricultural land can be further characterised assessing the variability related to soil-plant interaction. Several efforts have been made in the last decades in the integration of satellite data for the estimation of soil variability and properties. It is worth mentioning that the attempts performed until today used low spectral and/or spatial resolution optical data, allowing mainly qualitative determinations at the regional scale. The inference of quantitative information is usually performed by means of (multiple) regression analysis between bands (or band combinations) and soil properties, or classification approaches. More detailed quantitative information is exclusively possible through higher spectral resolution data. In the next few years the launch of satellites providing high spatial resolution hyperspectral sensors, such as the German ENMAP and the Italian PRISMA, could open up new possibilities for the remote estimation of soil properties.

New possibilities with Sentinels: The foreseen availability of Sentinel-1 and Sentinel-2 data will also provide operational multi-sensor observation of agricultural land. These data can be exploited to identify variability at field level related to soil (constant patterns) and weather plant interaction (seasonal patterns). According to the spectral bands acquired by Sentinel-2, some important issues arise, like the development of innovative indices and biophysical parameters (e.g., carotene, chlorophyll, nitrogen) taking benefit of the spectral characteristics of Sentinel-2 MultiSpectral Instrument (MSI). The development of vegetation status services describing the vegetative development will be of importance for irrigation policies. Integration with local and regional growing models has also an essential for the estimation of crop growth. Crop area delineation during the different growing seasons is needed to support the generation of refined crop statistics and crop growth profile information. Moreover, if governed by a *"free and open" access policy*, globally consistent crop maps would potentially support a wide range of local and regional management practices, including precision farming, crop-specific logistics, and assessment applications.

The compatibility of Senitnel-2 with the other Landsat missions will provide an unprecedented amount of multi-temporal data set availability. For this reason, the potential integration of Sentinel-2 and Landsat-8 capacities (through cross-calibration and inter-operation) needs to be deeply investigated. A continuous availability of high resolution time series with a short revisit time can provide information not only on crop area extent, but also on crop type and state. This information are indicative of the agricultural productivity of the different areas, therefore they constitute unique products for large scale agriculture monitoring using satellite remote sensing. The unique combination of Sentinel-2, in integration with ongoing international EO initiatives seems very promising in bringing serious benefits to agriculture and landscape analysis. Possibly, this initiative could also ensure a strong contribution of Europe to GEO and GEOSS. The application of Space technologies and Policies at Regional and local level could be of great help in the process of the implementation of such initiatives.

User-generated contents

Besides official sources of information, user-generated contents grow exponentially. It is promising to consider the massive amount of data provided by citizens in crowd-sourcing platforms and smart applications and in-situ sensors that provide observations of phenomena of our environment in real time. This poses new research challenges in spatial-based discovery, visualisation and facilitated consultation of on-line content. The availability of data in an interoperable manner is crucial for an effective integration with analytical models such as those that assist in decision-making. To develop a more participative and interactive Spatial Data Infrastructure (SDI) there is the need to implement novel methods to provide users with intelligent tools which can retrieve and exploit users' context, including their position and location, and evaluate users' needs to provide them information, tools and services appropriate for their particular requirements and situation.

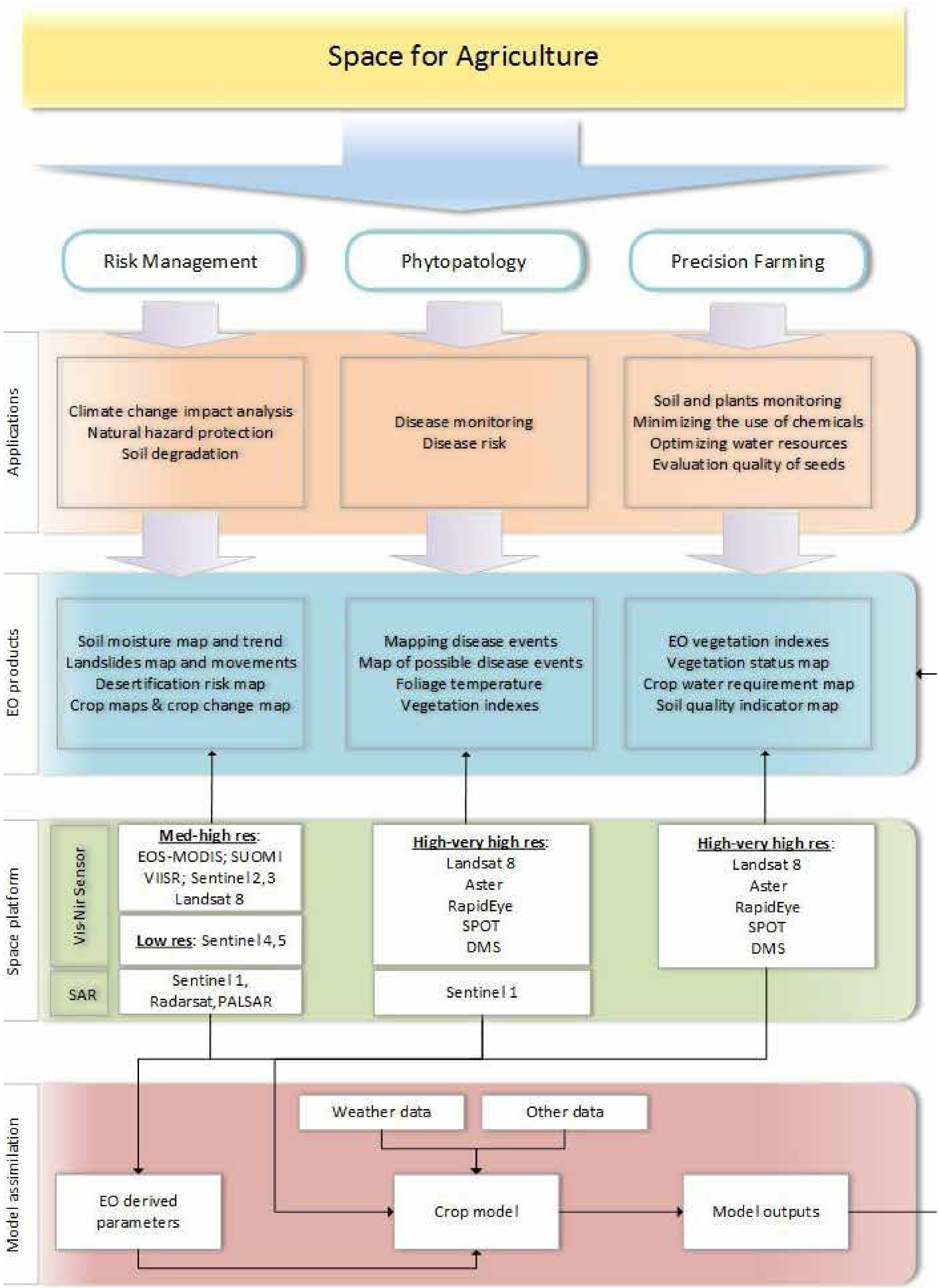


Fig. 1 Space for Agriculture diagram

Space Technology Applications for Agriculture

The diversity and cost-effectiveness of technological solutions to monitor agricultural systems and their surrounding environment are increasing rapidly, as a result of an important and progressive investment of public and private organizations in this sector. At public level, the main aim of supporting the development and use of such technologies is to **acquire up-dated synoptic spatial information at multiple spatial scales in order to contribute to the setup and improvement of new and more effective management and planning policies**.

A large number of indicators relevant to such policies can be repeatedly and consistently remotely detected. Remote Sensing data has many attractive features in the context of agri-environmental instruments. It is generally accurate and objective; it can be tuned to specific areas and regions of widely-varying scales; and because it is sensed from space, it can present a wide range of relevant data synoptically and without infringing national sovereignty.

- **Risk Management System for insurance purposes.** To develop new Risk Management tools for Agriculture. Technological developments, including remote sensing and satellite imaging, offer a vast array of climatic indexes and parameters, which can be used as underlying variables for insurance policies. Development of such instruments at the least possible cost, encompassing the widest set of climatic indexes and geographical areas could be very useful for insurance and reinsurance agriculture systems
- **Precision Agriculture and Precision Livestock**. The use of space technology to measure data to help crops and livestock management for minimizing inputs and maximizing productivity. The application of images and Space data could help to develop indexed for environmental protection minimizing the use of chemicals in agriculture and the bioaccumulation. Synergies between EO and Global Navigation Satellite System (GNSS) are also very beneficial for this domain.
- **Natural Hazards Protection**. The use of water, soil and natural resources to model natural hazards events, in order to develop systems of alarm for natural disasters such as Landslide, flooding, hail, fire, volcanoes, and associated disasters
- **Soil Degradation/Soil Quality**. In the incoming sustainable world context, soil-sustaining practices will become a crucial issue for agro food sectors. The sustainability of the practices can be defined by measuring changes in Soil Quality. The “Soil Quality” or “Soil Health” terms are crucial aspects that can be quantified by measuring selected indicators, thus reflecting any sort of degradation and help decision makers to evaluate and re-define the management of the agricultural land. The main threats to the soil ecosystems as they have been defined by the Soil Thematic Strategy (JRC-EC) need to be addressed and evaluated. The new management practices should minimize environmental and agricultural risks associated to soil degradation and climatic adverse events. The associated effects are worsening as mainly water erosion is increasing with climate change. In fact, all processes related to soil degradation are tightly related: soil losses from a field produce the breakdown of soil structure, the decline of organic matter and nutrients, the reduction of soil moisture, potentially phosphorus (P) and nitrogen

(N) contamination, and other types of degradation influencing nearby water bodies. According to Soil Thematic Strategy, this improvement in management practices in agriculture becomes particularly important in arid and semiarid environments.

- Drought monitoring. For example, two commonly-used satellite-based drought indicators are the Vegetation Health Index (VHI) and Vegetation Drought Response Index (VegDRI). The VHI monitors the health of vegetation regardless of the cause. Poor vegetation health, as indicated by the VHI, may be due to stress caused by drought, stress caused by too much water (e.g., flooding), or some other cause (such as insect infestation).The VegDRI product is a unique hybrid product, in that the VegDRI calculations integrate satellite-based observations of vegetation conditions with in situ climate data and other information such as land cover/land use type, soil characteristics, and ecological setting. The VegDRI monitors the health of vegetation as it is specifically related to drought.
- Irrigation management. Space Technologies can provide solutions for a better monitoring and more efficient use of the water resources - high spatial resolution satellite images are well suited to monitor the crop development and to derive crop evapotranspiration. This information can be even transferred to smart mobile devices via mobile apps (phones, tablets etc.) and used to plan a more sustainable use of water resources and hence to reduce the costs of irrigation.
- Landscape Protection and Land development. The use of indexes based in water, soil and natural resources could help to develop systems to evaluate and to survey ecosystems of special fragility. Beside Geographical information systems could survey areas of special interest and protected biota.
- Biodiversity Protection. High Nature Value farmlands (HNV) is the term used to describe broad types of farming that, because of their characteristics, are inherently high in biodiversity. Typically, these are low-intensity farming systems with a significant presence of semi natural vegetation, involving more traditional, low-intensity systems that tend to generate lower incomes from the market and also to receive the smallest CAP Pillar 1 payments. As Member States have to explore possibilities of implementing the concept of HNV into their own rural development programme (including the agri-environmental scheme), services and product based on space technologies can effectively support the definition (including delimitation), characterization and monitoring of HNV in EU.
- Rural Development. The application of Space Images as Geographical Information Systems could develop activities related to agriculture and livestock production to improve farmer's revenues.
- Support to Local Administrations in charge of controls on eligibility of farmers for EU aids in Agriculture. A significant role could be played by Space Technologies application and services at the time of EU aids assignments to farners and also to support the farmers in case of legal disputes related to infringements, as occurred in the past.

List of best practices collected across EU

NEREUS network has mobilised a collection of projects using Earth Observation and Space Technologies for purposes of Agricultural sector. During this first phase, 26 case studies across Europe were collected, including also some non-NEREUS Regions.

Annexes

ANNEX I - COLLECTION OF BEST CASE PRACTICES ACROSS EU REGIONS

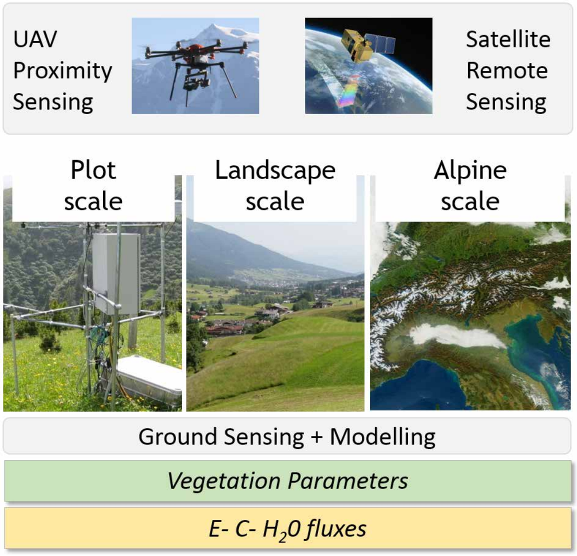
ALTO ADIGE/SÜDTIROL REGION

MONITORING MOUNTAINOUS AGRICULTURAL AREAS (GRASSLAND AND ORCHARD) WITH REMOTE SENSING TECHNIQUES INTEGRATED WITH PROXIMAL SENSING, GROUND DATA AND MODELS

MONALISA: Monitoring key environmental parameters in the Alpine Environment involving science, technology and application.
HiResAlp: An innovative framework for the Integration of multi-source data to determine soil moisture and evapotranspiration at high resolution in Alpine regions.

The challenge

In the Alps, economic activities, are strongly influenced by the particular environmental conditions of a mountainous area. For an effective management of such activities a precise and systematic comprehension of the environmental processes in all scales is essential and specific tools need to be developed to take into account the peculiarity of mountain areas. In the framework of two projects, MONALISA and HiResAlp financed by the Autonomous Province of Bolzano, an integrated system based on remote sensing, proximal sensing, ground data and model is developed to monitoring two main agricultural sectors of the region: managed grassland and apple orchard.



Space Technology Solution

The use of EO data is necessary to have a continuous monitoring of the Earth surface and thanks to the increased spatial resolution and revisit time of many satellites a detailed surveillance of many areas is now feasible. However, to have a complete view of the different processes at ground level, the remote sensing information need to be integrated with other data such as the ones coming from proximal sensing and ground stations as well from different kind of models. In this framework, the abovementioned projects are developing:

- Methodologies and tools for monitoring key environmental parameters for vegetation from the plot scale to the scale of more than 1000 km^2 by integrating satellite based remote sensing, drone based (Unmanned Arial Vehicle – UAV) remote sensing, ground based remote sensing, ground sensors and modelling.
- Methodologies and tools to integrated remote sensing data with models (hydrological model and two source energy balance model) to predict two key variables that is soil moisture and evapotranspiration.

Implications

Regional users and local companies are directly involved in these projects since the beginning thus allowing a direct flow from project outcome to relevant applications. The outcomes of the projects can be of interest for authorities related to water and agricultural management.

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ALSACE REGION

EARTH OBSERVATION SATELLITES: A TOOL FOR AGRICULTURAL PLANNING IN THE CONTEXT OF BIODIVERSITY CONSERVATION

Within the context of insuring the long-term viability of the common hamster populations in France, the French Ministry of Environment turns to Earth Observation and SERTIT to analyse and monitor the environment of the rodent in order to rapidly assess the quality of the hamster's biotope.

The challenge

The Common Hamster is an endangered species in Alsace. The main reasons of the current critical situation are agricultural: the reduction of winter crops over the past decades is particularly unfavourable because the rodent needs food and protection after its hibernation, a very vulnerable period for the hamster. Spring crops land-parcels, mostly maize in this case, are still bare soils in early spring. Moreover the hamster habitat is lacking stability because of crop turnover and parcel enlargement. The landscape is also more and more fragmented by road infrastructure and urban development.

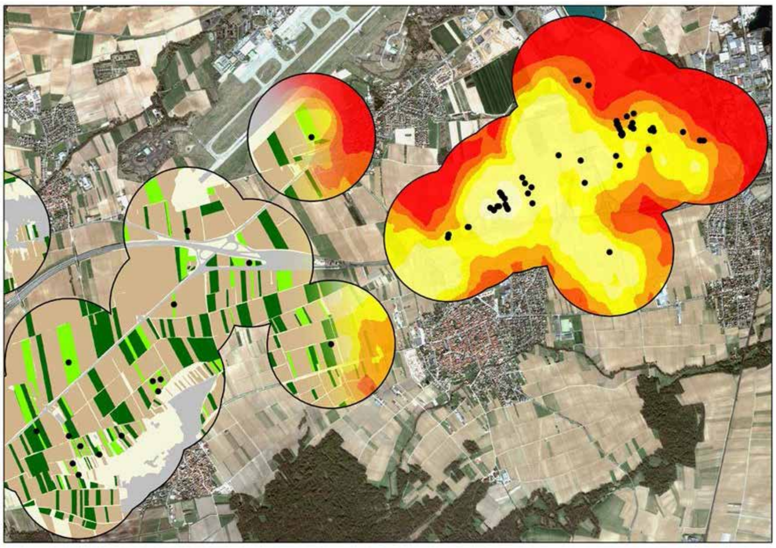
The challenge here is to give to French ecological institutions the baseline situation of the Common Hamster's environment in order to assess the concrete actions of biodiversity conservation and to know where actions have to be carried out.

Space Technology Solution

Recent work on the hamster case in Alsace is particularly representative of the usefulness of Earth Observation imagery for environmental observatory and biodiversity conservation.

The early spring landcover mapping of areas populated by hamsters in Alsace, using high or very high resolution satellite imagery (SPOT5/Pléiades, CNES), highlights hamster-friendly crops as well as unfavourable areas – such as bare soils and artificial features – giving an accurate idea of the situation at the end of the rodent's hibernation period, which appears as a key moment for hamster survival.

The mapping of the hamster's habitat clearly underlines landuse threats to the rodent in the area: the fragmentation of their biotope by road infrastructure, isolating populations; the extent of bare soils - spring crops that do not provide food or cover for a long time after hibernation; the proximity of urban areas, which continuously erode their natural environment.



Satellite imagery, derived landuse mapping and ecological indicator over burrows areas [© SERTIT]

Unfavourable environments and human pressures on the hamster populations are highlighted through detailed geographic analysis.

Therefore, annual hamster environment monitoring, using satellite imagery, also emphasizes the positive effects of the species conservation actions.

However, the survival and reproduction of the common hamster depend on a fairly dense spatial distribution of winter crops. The analysis through density indicators of favourable crop spatial distribution, highlighting favourable and unfavourable areas, offers a vision of possible networks and their quality or otherwise indicates if the biotopes are connected or not, and hence, reveals ecological corridors at a local scale.

Thus, the annual monitoring of winter crop densities, which shows major changes in favourable area distribution from year to year, is required to have an idea of habitat stability, network evolution, and also gives an overview concerning the efficiency of hamster protection policies and actions.

Implications

This innovative action emphasizing the benefits of Earth Observation data in characterizing biotopes and being operational for the hamster case in Alsace today, it would be particularly interesting to reproduce this work over other European regions as well as for other species – endangered or not – and to apply it to the whole green infrastructure, at different scales of work.

Earth Observation derived products enable a global and accelerated assessment of operational efficiency of biodiversity conservation actions. The French Ministry of Environment being particularly convinced of the results provided, this analysis is now a routine methodology listed in the current action plan for the species.

Acknowledgements

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ANDALUSIA REGION

GPS-EGNOS BASED PRECISION AGRICULTURE USING UNMANNED AERIAL VEHICLES

FieldCopter. Galileo FP7 R&D programme funded project in partnership with two academic institutions (FADA-CATEC and CSIC) and four companies (TheraSphere, Flying-cam, Aerovisión & Aurea Imaging) to provide state-of-the-art multi-spectral cameras on UAS that deliver the right information in the right time on the right spot, developing a complete solution for UAS sensing. Unmanned Aerial Systems (UAS) are an up-and- coming method in providing farmers with (near) real time sensing information for precision agriculture applications such as water stress monitoring, detection of nutrient deficiencies and crop diseases.

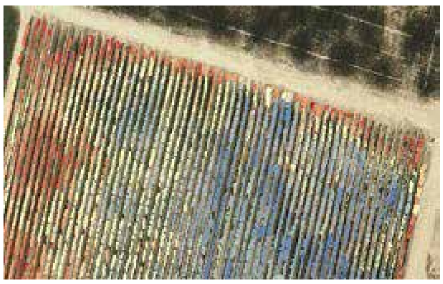
The challenge

Existing components are brought together and required high precision navigation of EGNOS is added in order to create an autonomous flying camera that follows a predefined pattern. FieldCopter has demonstrated its operational viability in two distinct cases: potato growth- & vineyard monitoring. Next to potatoes and vineyards, the FieldCopter service has explored simultaneously for other promising high value crops, such as vegetables, flowers and orchards (apples, oranges).

Space Technology Solution

The consortium aims at a complete operational service, bringing together the necessary competences assembled on the platform: the sensing aspects, the navigation expertise and the market knowledge. FieldCopter allows farmers to create economic and ecological benefits through optimal use of resources like water, nutrients (potassium, nitrogen) and crop protection agents. The initiative has been also be useful to demonstrate how powerful the European high precision navigation system EGNOS is and what advantages its complete operational service has in the area of precision agriculture.

Implications



In the Mediterranean region irrigation is the main topic for the advisory service. The availability of water is an expensive and limiting factor for optimal yield. By using thermal imagery, water content and stress levels can be monitored and specific advice on the optimal irrigation regimes can be given. FieldCopter helps monitoring and ultimately improve the effectiveness of the irrigation activities to minimize the environmental impact of the agricultural practices. FieldCopter's applications also contribute the reduction of fertilizers and crop protection agents through variable rate application. The UAS-images are processed to biomass index maps, and variable rate application advices for fertilization, crop protection, and irrigation.

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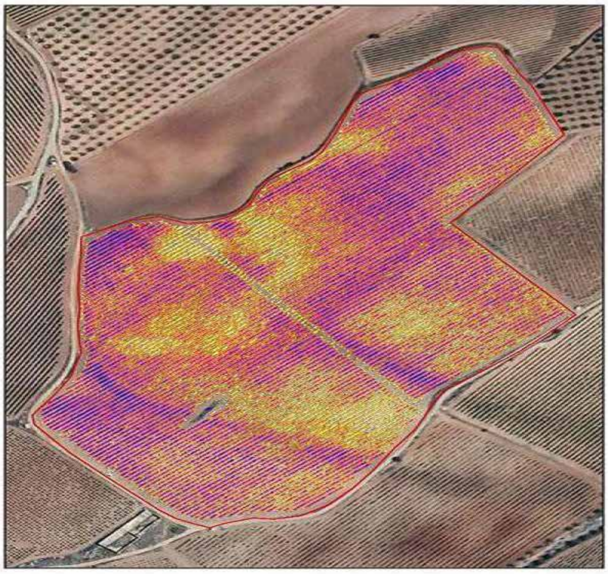
ARAGÓN REGION

VERY HIGH RESOLUTION IMAGERY FOR VINEYARD SEGMENTATION

Precision agriculture in general, and precision viticulture in particular, are areas where remote sensing data can be extensively and intensely used. FADOT has supported the "Terroirs of Campo de Borja" project by providing vegetation indexes derived from very high resolution images for a complete wine protected denomination of origin area.

The challenge

The main objective of the "*Terroirs of Campo de Borja*" project was to identify homogeneous units of territory (i.e. terroir units) in this wine protected denomination of origin area at a detailed scale in order to know the characteristics of the wines produced in each unit of territory. The results of this classification will be then used to define better wine production and management strategies. The project analysed all the factors that affect the vine, being the most important factor the production of the soils map at a 1:25.000 scale.



Heterogeneity, from vegetation vigour point of view.

Space Technology Solution

Electromagnetic radiation reflected by vineyard, both in visible and near infrared regions, can be registered in satellite images and processed to obtain important parameters as the greenness of the plant. The vegetation indexes obtained from satellite imagery can be used to segment vineyard exploitations into homogeneous areas from vegetation vigour point of view. This segmentation is useful as a tool to support the decision making process since it provides both the variability inside a plot and the variability between plots.

Implications

Processing very high resolution images is a valuable tool for many aspects of vineyard management. The integration of the information derived from these images into a geographical information system (GIS) together with data obtained with in situ sensors allow us to visualize, look up and process al data related to the vineyard and its environment. It helps growers improve grape quality, identify disease, save time and resources and reduce the environmental impacts.

Acknowledgements

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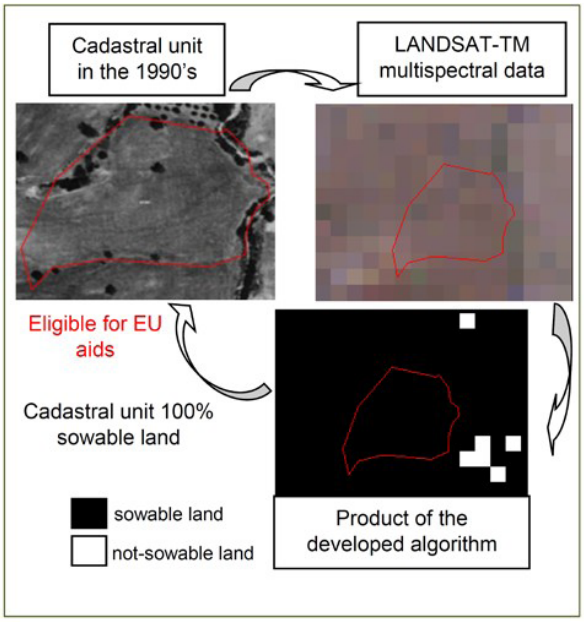
BASILICATA REGION

SPACE TECHNOLOGIES FOR PUBLIC ADMINISTRATIONS IN CHARGE OF CONTROLS RELATED TO THE ELIGIBILITY OF FARMERS FOR EU AIDS IN AGRICULTURE

An ESA Pilot project, funded by Basilicata Region, was carried out by the School of Engineering (University of Basilicata) in collaboration with the Department of Agriculture and Forestry (Basilicata Region). The project was devoted to verify the potential of multispectral remotely sensed observations to ascertain eligibility conditions to the European funds regulated by the Council Regulation (EEC) N. 2078/92 "on agricultural production methods compatible with the requirements of the protection of the environment and the maintenance of the countryside".

The challenge

The main challenge of the project was to offer an independent, objective method to evaluate the status of some regional agricultural areas in the 1990's in order to support Basilicata Region in clarifying the position of some farmers whose eligibility to receive EU aids (according to EEC N. 2078/92) was in doubt.



Space Technology Solution

Based on LANDASAT-TM sensor a multi- spectral, multi-temporal algorithm was developed suitable for identifying areas were actually sowable lands before the farmer application for EU contribution, as required by the European regulation.

Implications

The project results helped the Basilicata Region to take the final decision about the eligibility for received EU aids. Such a pronouncement was strongly invoked by all involved farmers who underwent a dramatic economic situation due to the suspension of whatever contribute from EU until the dispute solution.

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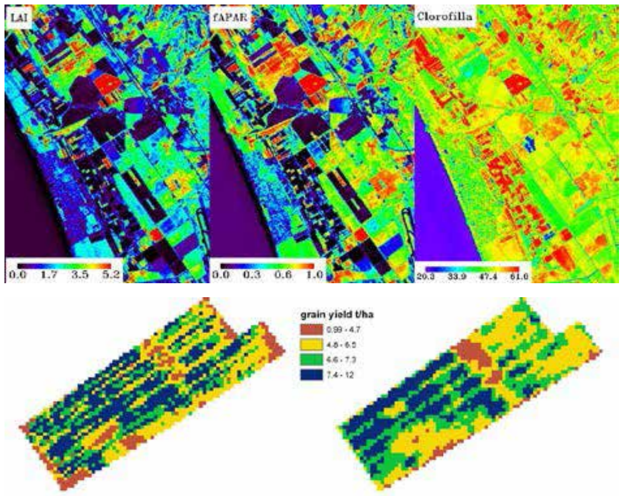
BASILICATA REGION

SPACEBORNE MULTI/HYPERSPECTRAL DATA FOR PRECISION AGRICULTURE: ALGORITHM ADJUSTMENT AND VALIDATION TAILORED FOR MEDITERRANEAN AGRICULTURAL AREAS

The challenge

The main challenge of the project consists in identifying soil/biomass spatiotemporal heterogeneity at the field scale to support site-specific farming management and decisions in highly fragmented Mediterranean areas such as the Basilicata Region. The spatiotemporal pattern maps (static over the years) will be used to define the "elementary units" both for farming management and for model simulation either at the field or the within- field scale. Moreover, additional challenge in the use of next generation satellites consists in tuning the algorithms for retrieving plant parameters (e.g., LAI,FAPAR and Cab) using neural network algorithms optimized for crops present in the Basilicata region. The high spatial resolution Sentinel-2, and hyperspectral (PRISMA, EnMAP, VENµS) spaceborne sensors, will allow the development of improved cropland products such as LAI, FAPAR, and chlorophyll a+b (Cab) especially targeted at precision agriculture applications.



Example of LAI, FAPAR and Cab maps retrieved-from CHRIS-Proba data

Space Technology Solution

Available multispectral (SPOT, RapidEye, Landsat) satellite imagery time-series can be used to retrieve plant and soil parameters accounting for spatiotemporal heterogeneity in agricultural production models, which can also be used to explore the suitability of different management practices. The high accuracy and quality and the revisit time of the forthcoming high spatial/spectral resolution spaceborne data (Sentinel-2 and PRISMA, EnMAP, VENµS) will also provide the necessary framework to move from prototypes of continental scale monitoring systems to operational services useful for regional authorities and agro-market operators.

Implications

Agricultural sector especially for Southern Europe has to maintain competitiveness reducing production costs and minimizing environmental impact of agricultural practices. On 2003, EU Agriculture Ministers agreed on fundamental reforms to Common Agricultural Policy (CAP). A reliable agriculture management system requires therefore both high temporal and spectral/spatial resolution data able to provide information on crop fields. The availability of such information is crucial to support the development of more productive and sustainable farming systems in order to increase competitiveness and achieve environmental requirements such as reduction of greenhouses gas emission, water consumption, soil contamination and degradation. This is even more crucial for the Southern Mediterranean regions, such as the Basilicata, where human and natural driving forces have a strong impact on agriculture and its products.

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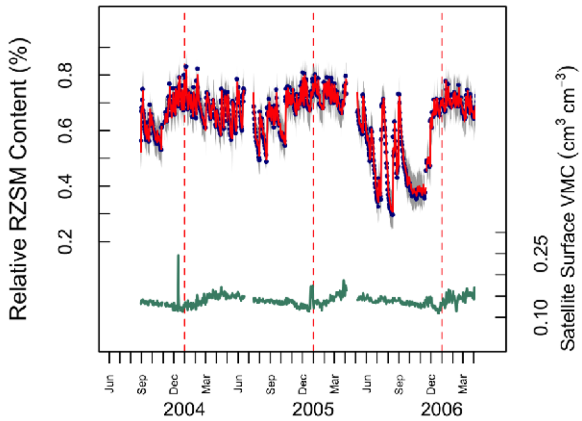
BASILICATA REGION

SMAR: A PHYSICALLY BASED MODEL FOR THE ESTIMATION OF ROOT-ZONE SOIL MOISTURE FROM REMOTE-SENSING MEASUREMENTS

In the present work, we developed a new formulation for the estimation of the soil moisture in the root zone based on the measured value of soil moisture at the surface taken from remote-sensing data. The proposed model derived from a simplified soil water balance equation that provides a closed form of the relationship between the root zone and the surface soil moisture with a limited number of physically consistent parameters. This method coupled with an Ensemble Kalman Filtering (EnKF) allow the description of soil moisture over large areas.

The challenge

The goal of halving the proportion of malnourished people, while ensuring environmental sustainability, is the world largest water related challenge. There is no doubt that water management will play a crucial role in the sustainable development of agriculture. In this context, the monitoring of soil moisture is the key variable, which synthesizes the interaction of climate, soil, and vegetation. However, in situ soil moisture observations are lacking over large spatial scales. A viable alternative strategy for obtaining spatial fields of soil moisture is from satellite remote sensing, which can provide continuous and large scale monitoring of the surface soil moisture state.



Observed (blue points) and predicted (red lines) relative root zone soil moisture time-series at at the Mammoth Cave SCAN site in Kentucky. The grey shaded region is the 95% confidence interval calculated from the predictive covariance. The green time-series is the AMSR-e satellite near-surface volumetric soil moisture content used to drive the model.

Solution

Soil moisture analytical relationship (SMAR) is a model for the description of soil moisture in the root zone based on the time series of remote-sensing surface soil moisture data (Manfreda et al., 2014). SMAR has a physically consistent structure, with parameters that may be estimated from the physical characteristics of the site under investigation. SMAR model assumes that the soil is composed of two layers, one at the surface with a depth of a few centimetres (equivalent to the retrieval depth of the satellite sensor) and a second one below with a depth that may be assumed coincident with the rooting depth of vegetation (of the order of 60–150 cm). The model define an analytical relationship between the surface soil moisture remote-sensing measurements and the root-zone soil water balance equation where the infiltration term is not expressed as a function of rainfall, but of the soil moisture content in the surface soil layer. This allows the derivation of a function of the soil moisture in one layer as a function of the other one.

The SMAR model can be coupled with an Ensemble Kalman Filtering (EnKF) approach that may provide a strategy to monitor soil moisture content over large areas. This method has been preliminary tested over the entire territory of United States where a dense soil moisture network (SCAN) is available for the validation of the procedure. Results show that this new approach provides good description of soil moisture and it may provide quantitative measures of the soil moisture in the rooting system.

Implications

Agricultural sustainability and productivity are assessed with reference to water productivity (defined as the ratio between yield and total supplied water), yields, water requirements, and their variability—a crucial element for food security and resource allocation planning. Plants need to maintain an adequate level of water in their tissues to assure both growth and survival; they also require a continuous flux of water to perform vital processes such as photosynthesis and nutrient uptake. Since water is absorbed from the soil, it is obvious why soil moisture deficit has such an essential control on plant conditions. Remote sensing can provide soil moisture data but only at the skin surface, but the proposed procedure may help to derive the soil water content in the rooting system and therefore monitor crops. These data becomes an important tool that helps in decision-making about crops and agricultural strategies.

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BASILICATA REGION

SATELLITE TECHNOLOGIES FOR VINEYARD MANAGEMENT

A Geospazio Italia S.r.l. solution for a rapid assessment of a vineyard management such as irrigation, pest and disease control, harvesting, soil and canopy management through the use of time-series of multispectral satellite data.

The challenge

The main challenge was to develop a set of services and products, based on remotely sensed data, to improve farming operations and management decisions. In particular, the goal was to monitor events of the vineyard's phenology, such as flowering and veraison, which are crucial for grapevine reproductive and maturity processes, through the use of space technologies.

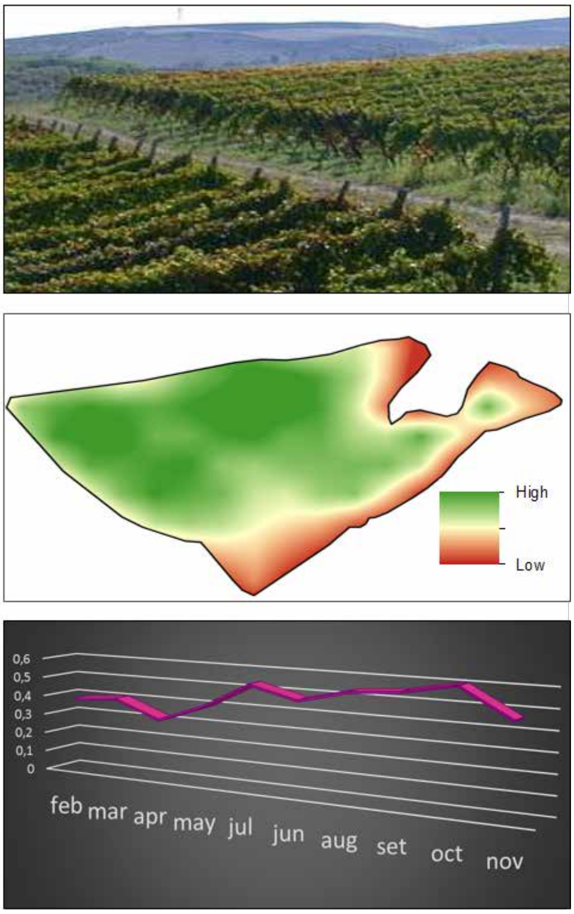
Space Technology Solution

Multispectral time-series of satellite data, LANDSAT ETM+ (Enhanced Thematic Mapper Plus) and Sentinel-2 MSI (MultiSpectral Instrument) first of all, were used to perform a near-real time monitoring of vegetation index, indicative of the state of the growing, to provide farmers with supporting and prescription maps.

The satellite images, moreover, were used to define a suitable algorithm to detect space-time variations of satellite agronomic parameters, to identify anomalous behaviour and provide early warning to drive and determine the best timing of vineyard operations.

Implications

The developed solution help the farmers to take a timely decision in vineyard management. It can be integrated within an operational tool, based on remote sensing and ground data, suitable for large vineyard area monitoring.



Upper part: a picture of vineyard testing area. Middle part: retrieved vegetative map. Bottom part: time series of vineyard vegetative status.

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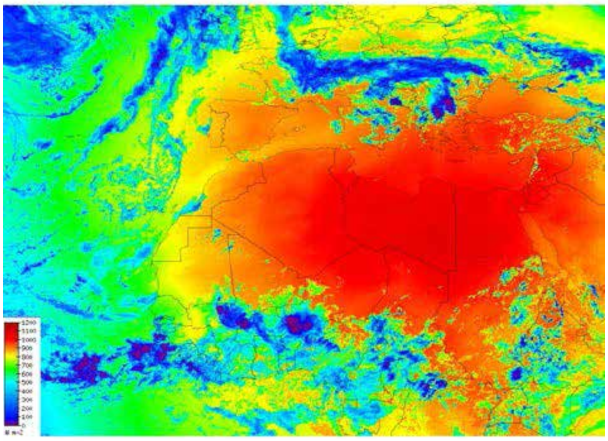
BASILICATA REGION
AGRO-METEOROLOGICAL VARIABLES

The challenge



Example of surface solar irradiance map.

Agricultural models need meteorological information to properly estimate crop development and yields, incidence of pests and diseases, water needs and fertilizer requirements. The necessary meteorological variables can be derived from 3 different sources: 1) direct measurements from automatic weather stations; 2) meteorological models and 3) satellite measurements. Direct measurements derived from automatic weather station networks at the surface are often not sufficiently dense and their reliability and inter-calibration are not always accurate. Meteorological models, physically based, can be used to generate either short-term weather forecasts or longer-term climate predictions; the latter are widely applied for understanding and projecting climate change. The new generation of geostationary satellite offers an opportunity to improve the estimation of some parameters used in the agricultural model such as solar irradiance at the surface, surface temperature, total water vapour column, cloud cover and classification.

Space Technology Solution

We developed different algorithms to retrieve several accurate parameters used in the agricultural model such precipitation, cloud cover, extreme events, surface temperature, humidity and solar irradiance at the surface from IR/VIS and microwave sensors. At same time we are working (EU ERMES project) to put on an integration strategy of ground, satellite and models data in order to offer the best meteo input data to agricultural model.

Implications

Agricultural sector especially for Southern Europe has to maintain competitiveness reducing production costs and minimizing environmental impact of agricultural practices. On 2003, EU Agriculture Ministers agreed on fundamental reforms to Common Agricultural Policy (CAP).
The availability of information on meteo conditions in space and time, is a crucial issue to support the development of more productive and sustainable farming systems in order to increase competitiveness and achieve environmental requirements such as reduction of greenhouses gas emission, water consumption, soil contamination and degradation.

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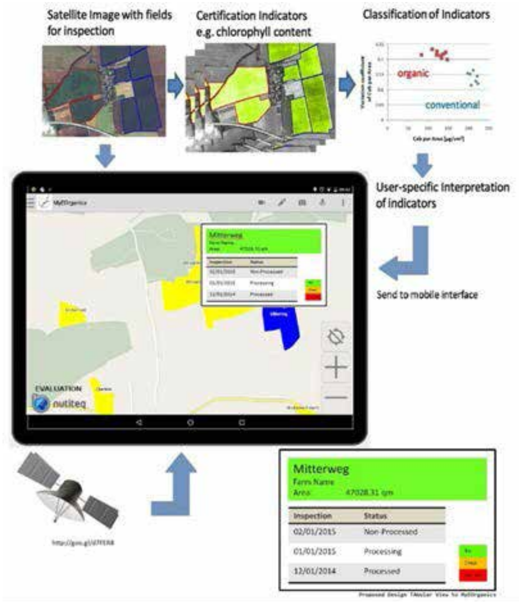
BAVARIA REGION

MYEORGANICS – MOBILE TECHNOLOGY SUPPORTING SUSTAINABLE AGRICULTURE

myEOrganics is an EU funded project in partnership with two clusters and 3 companies to develop a monitoring system based on GNSS and Earth Observation (EO) in the sector of organic agriculture. The objective is to develop a mobile app that displays localised information on fields, based on processed EO data, to support organic certification. The project is being undertaken by bavAIRia (coordinator), Vista, PCAgrar, Ecocert and Infopole.

The challenge

Certification of organic farming is a lengthy and cost intensive process and at the same time fundamental for food security and consumer trust. It comprises a set of steps to be performed by the auditor, with the on-site visits of fields being one of the most important points. In particular the on-site visits consume a significant amount of time and are not possible to be planned in advance, as no indications exist which fields might be worth visiting and which fields are unproblematic.



Data flow of myEOrganics service.

Space Technology Solution

The myEOrganics project aims at delivering a service for certification bodies that allows auditors to being target fields that have a high probability of not being compliant to EU organic regulations. The myEOrganics application will support the auditor to prepare and guide him during the audit. It also allows the management of the auditing process itself. The service will use GNSS to facilitate the geo-localisation of the auditor in the field and Copernicus components to provide him with information regarding the compliance of the fields with the requirements of the regulation. High resolution EO data is used to analyse a set of certification indicators and perform an interpretation of these indicators to provide the indication for organic compliance.

Implications

Space-based services offer a great possibility for the agriculture and forestry sector as low cost, high resolution satellite data becomes available. The challenge though is, to set the regulatory basis that enables service providers and users to efficiently utilize these services. Furthermore, a large variety of different data sets on e.g. field data hamper large scale implementation of satellite-based services in this sector and are one of the most important challenges to overcome in the years to come.

Project Partners: bavAIRia e.V., Vista Geowissenschaftliche Fernerkundung GmbH, PC-Agrar Informations- und Beratungsdienst GmbH, Ecocert SA, Infopole Cluster TIC Moritz Fontaine, bavAIRia e.V., Friedrichshafener Str. 1, 82205 Gilching, Fontaine@bavAIRia.net, project manager myEOrganics.

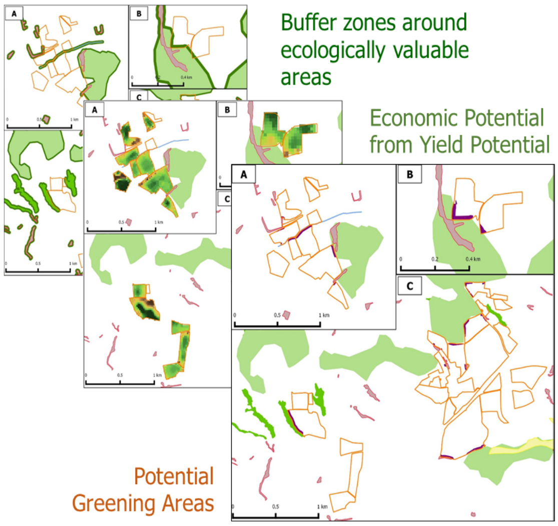
BAVARIA REGION

COMBINING SATELLITE IMAGERY AND OPEN DATA TO DERIVE YIELD POTENTIAL FOR GREENING

The MELODIES-Project is an EU FP7 project, coordinated by the University of Reading. It develops innovative, sustainable services based upon Open Data for users in research, government, industry and the general public in a broad range of societal and environmental benefit areas. Vista GmbH develops a Site-Specific Information Service for Land Management. The service supports land management decisions through the evaluation of the economic and ecological value of the land surface.

The challenge

Europe's agricultural landscapes are supposed to become "greener". Within the last years the European Union has implemented various new tools (laws as well as funding programs) in order to support a more sustainable and environmental friendly usage of our natural resources. The challenge lies in combining environmentally-friendly and sustainable management with the demands for high-quality and affordable agricultural products.



Calculation of potential Greening areas for a Bavarian farm.

One of those tools that the EU has developed to achieve this goal is the so called "Greening" which is part of the recently reformed Common Agricultural Policy of the EU. From 2015 onwards, parts of the subsidies farmers are receiving from the EU will only be paid if the farmers apply environmental friendly land management on their arable area. One core point of the Greening Directive is the designation of 5% of the arable area of a farm as ecological focus areas on which agricultural usage underlies strict regulations or is terminated completely.

But how are farmers supposed to know where to implement those ecological focus areas and which fields to keep in agricultural production?

Space Technology Solution

Within the MELODIES project, we develop a service that provides decision support for farmers to help them to identify areas within their arable land that are especially suitable to serve as ecological focus areas. We are addressing this issue by investigating productivity variations within the arable area - both, within and between fields - and linking this information with freely available land use and governmental data. With this information land management can be optimized and both - areas of high as well as areas of low productivity - can in the future be managed in a more economical feasible and environmental-friendly way.

We identify spatial differences of productivity within agricultural fields using time-series of Earth Observation (EO) data from which we investigate plant-growth patterns indicating differing productivity within the agricultural unit. By using time series of five to ten years we can assure that the patterns we see are stable over time and independent of the planted crop species. We combine this information with the results of a crop growth model to derive absolute yield potential for each given area.

Then, we combine the satellite-derived information about the field productivity with available open data which shows us the spatial connection to surrounding habitats of high biological diversity such as forests, rivers and hedges. Establishing ecological focus areas in direct relation to these habitats ensures that species can colonize the area and travel between different habitats, thereby stabilizing the genetic variation of the population.

Implications

In times of a growing global population, it seems unwise to take highly productive areas out of agricultural usage to fulfill the Greening requirements by the EU. If we have to put areas out of usage we would therefore prefer to choose fields with poor growing conditions for agricultural crops. This is not only due to economic reasons, but makes a lot of sense from the ecological point of view as well. Bad growing conditions mean that higher amounts of fertilizers and pesticides as well as energy-consuming management techniques have to be applied on an area in order to produce yields that meet our demands concerning quality and quantity.
Using both the yield potential, and thus the productivity of a location, as well as the proximity to different ecologically valuable resources (e.g. rivers, forests, FFH areas) as input to decide which areas are best taken out of production allows a decision that is both efficient and ecologically meaningful, supporting both food security ("feeding 9 billion") as well as our environment.

Acknowledgements

The work presented has been funded within the EU FP7 project MELODIES (Grant Agreement 603525).

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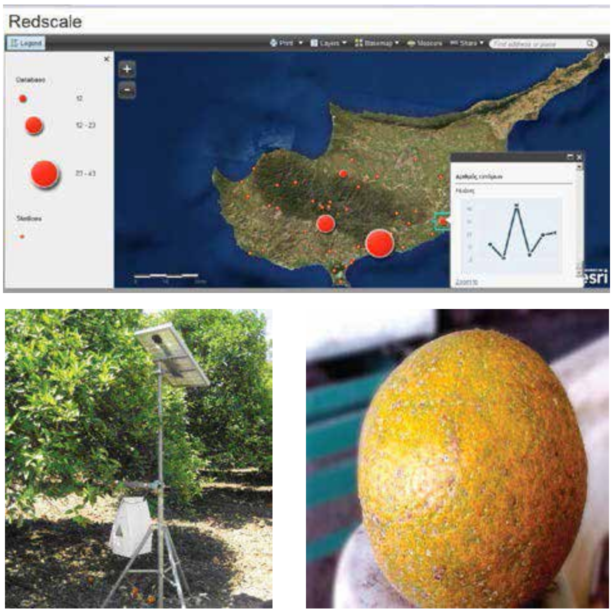
CYPRUS

DEVELOPMENT OF AN AUTOMATED SYSTEM FOR MONITORING REDSCALE POPULATION USING IMAGE ANALYSIS, WIRELESS NETWORKS AND GIS TECHNOLOGIES

A Cyprus Research Promotion Foundation (CRPF) funded project in partnership with an academic and research Institution and two SMEs: Cyprus University of Technology (CUT), Agricultural Research Institute of Cyprus, Cyprofresh and CNE Technology Centre to develop an automated trap for continuous monitoring / identification of the RedScale population.

The challenge

The Red Scale «Aonidiella Aurantii» is a major citrus pest on a worldwide scale. It attacks all the vegetative parts of the tree, from the trunk to the fruit, but it usually prefers new vegetation and fruits, particularly in the shaded parts of the tree. When the attack is strong, a general weakening of the tree is observed (mostly drying and falling leaves) as well as a deformation of the fruit. The fruits are smaller causing the reduction of juice's quality and quantity. The damage cause up to 25% drop of the citrus production.



WebGIS platform for monitoring RedScale population (top). A trap placed in the field (bellow).

Space Technology Solution

The aim of the research program is to develop an automated, energy- independent trap for continuous monitoring / identification of the RedScale kind of parameter is temperature which is related to day-degrees growth calculation for estimating RedScale population. For this purpose satellite image data were used in order to estimate LST and then to correlate with air temperature. The use of satellite data has many advantages against traditional techniques such as local meteorological stations places in agricultural areas, since they can provide a synoptic coverage on a systematic daily basis.

Implications

The integration of remote sensing and wireless sensors can reduce damages to agricultural products due to red scale attacks, with significant economic and environmental benefits. The database can store all data from the traps of a region (e.g. Cyprus region). The collection of all data in a single database facilitates data exchange. In the same database, satellite thermal images are stored, which can be used for degree-days calculation for trap-free areas.

Acknowledgements

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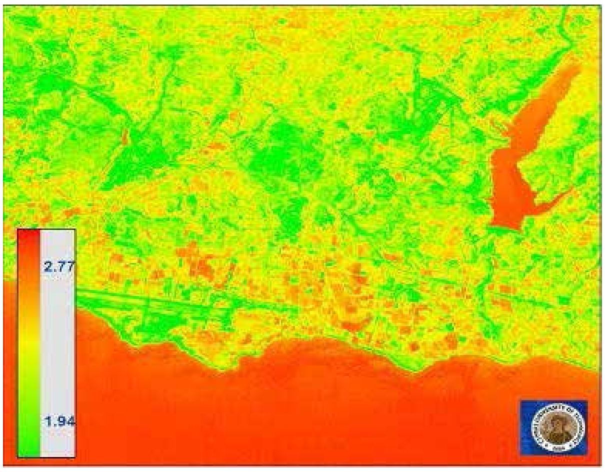
CYPRUS

ESTIMATION OF EVAPOTRASPIRATION IN IRRIGATED CROPS USING SATELLITE REMOTE SENSING AND WIRELESS SENSORS

A Cyprus Research Promotion Foundation funded project in partnership with three academic Institutions: University of Technology, Agricultural Research Institute of Cyprus and National Agricultural Research Foundation of Greece so as to develop a monitoring system based on Cyprus.

The challenge

The need for an efficient irrigation water management is of vital importance in Cyprus. Estimating crop evapo- transpiration (ETc) from remotely sensed data could be a very helpful tool for Policy makers. The project aims to estimate ETc using remotely sensed data and in situ field data, such as field spectroradiometric data, Leaf Area Index (LAI) and crop height (CH).



ETc map of the area of interest
(Landsat 5 TM image of 7 July 2009).

Space Technology Solution

Remotely sensed data were correlated to field spectrodadiometric data in order to avoid direct measurements of crop canopy factors, in the future. These empirical equations have been used to provide the final ETc maps using the Surface Energy Balance Algorithm for Land (SEBAL) methodology. Finally an economic assessment of the irrigation costs using old and the new data regarding irrigation was made to test if remote sensing can play an important role in the irrigation management.

Implications

Estimating crop evapotranspiration (ETc) is a crucial parameter for monitoring water balance. Further to empirical equations or sophisticated equipments – such as lysimeters – often used for calculating daily ETc, remote sensing data have been also applied successfully in many parts of the world. The latest has expanded the capabilities of local authorities, since satellite imagery provides a systematically and overall coverage of a vast agricultural area. The final results can be then provided in near –real time to the end users using GIS technology and friendly interfaces.

Acknowledgements

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EAST MIDLANDS REGION

HIVACROM – HIGH-VALUE CROP MONITORING

A crop monitoring service using EO data to accurately estimate crop yields (initially potato and sugar beet) is proposed as part of the project led by CGI IT UK Ltd (formerly known as Logica) in partnership with the University of Leicester, Agspace and the Satellite Applications Catapult. The initial feasibility project was funded by the UK Technology Strategy Board in 2012-2013 and is now considered for further support by ESA.

The challenge

The UK potato and sugar beet industries are worth over £1bn per year. Present space-based monitoring services are failing to deliver for those crops that are of high value for the UK. HiVaCroM developed a proof of concept for a near-real-time, dynamic integrated crop monitoring service derived from Earth Observation and in-situ data.

Potato fields in Lincolnshire as imaged by Rapideye.

Space Technology Solution

The HiVaCroM project is focused on the development of high-resolution datasets, and it set to utilise Sentinel-2 and commercial imagery (<10m), to accurately estimate key canopy variables in high-value crops, as well as producing a timely yield forecasting service for the agricultural supply chain.
The routine production of HiVaCroM datasets related to the crop geophysical variables, for example chlorophyll content (an indicator of crop health) and crop canopy cover (an indicator of crop development) are of great importance to farmers, agronomists and producers alike.

Implications

HiVaCroM allows for scalability; with the use of Copernicus data, the service can provide mass market access for targeted agronomy; mapping and identifying areas of low crop growth as a result of disease, nitrogen deficit, poor seeding and water stress, as well as providing producers with a macroscopic monitoring tool of their cropped area.

CGI IT UK Ltd and the University of Leicester.

LAGADAS REGION

"AGRO_LESS – JOINT REFERENCE STRATEGIES FOR RURAL ACTIVITES OF REDUCED INPUTS" (B3.11.02) ERDF.

The AGRO_LESS project is part of the cross-border European Territorial Cooperation Programme "Greece-Bulgaria 2007-2013", and is co-funded by the European Union (European Regional Development Fund - ERDF) and National Funds of Greece and Bulgaria. The partnership of the project consists of Greek and Bulgarian Universities, Municipalities and Research Centers and aims to establish common reference strategies for the implementation of reduced input agricultural practices in the cross-border area by introducing rural population with the concept of site-specific crop management, which through an information and new technology farm management system will be able to identify, analyze and manage variability within fields for optimum profitability, sustainability and protection of land resources.

The challenge

The overall objective of the project is the adoption of a strategic reference framework in a cross-border region for the support of the rural population in the application of reduced input agriculture driven through the practises of agricultural activities (fertilization, irrigation and crop protection) leading to reduced impact of agro-products on the environment and maximising the product quality of agricultural goods.

Space Technology Solution

The specific objective of the project is the development of innovative Earth Observation services, Group on Earth Observation Data Bases and spectra libraries for agricultural and environmental monitoring needs and support systems for management decisions applications.

The expected results of the project are: 1. Maximization of production by identifying the areas of reduced productivity and managing them in a different way compared to the whole field 2. Through reduced input operations farmers are confronted with European Directives that require them to comply with legislative rules concerning farm management and environmental issues 3. Economic improvement of crop production through the reduced usage of fertilizers applied and water 4. Provides opportunities for better resource management and so could reduce wastage 5. Minimises the risk to the environment particularly with respect to nitrate leaching and groundwater contamination via the optimisation of agrochemical products. 6. Increase in product quality and yield stability.

Implications

AGRO_LESS project aims to introduce public's perception with the use of new technology tools for achieving good crop management practises that will ensure less inputs thus economical and environmental benefits.

The implementation of reduced input practices follows European policies guidelines on protecting the environment and increase public's awareness on environmental issues. The project is also compatible with the Common Agricultural Policy (CAP) and the Water Framework Directive (WFD), offers various possibilities for combining the efforts of the two policies in order to achieve positive environmental effects.

The overall objective of the project is the adoption of a strategic reference framework in a cross-border region for the support of the rural population in the application of reduced input agriculture driven through the practises of agricultural activities, leading to reduced impact of agro-products on the environment and maximising the product quality of agricultural goods and increase citizens' quality of life through achieving good quality products.

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LAGADAS REGION

ENVIRONMENTAL DATA MANAGEMENT SYSTEM FOR ENTREPRENEURSHIP AND COMPETITIVENESS SUPPORT (MIS 482385)

Inter-Balkan Environment Center is responsible for implementing the first programme in Greece that complies entirely to the principles of Group on Earth Observation. The project aims at the development and operation of environmental data management system for entrepreneurship and competitiveness support under the Operational programme “Digital Convergence” / “National Strategic Reference Framework 2007-2013” / European Regional Development Fund and provide numerous digital services for the sustainable use of natural resources in the context of agricultural, coastal and water management practices.

The challenge

The main challenge of the project is focused on the support of entrepreneurship and competitiveness of businesses and individuals whose professional activity is related to the natural resources and on the information provided to citizens and to the administration bodies in order to organize their daily activities, information on emergency and environmental issues, civil protection and providing environmental information to enhance and support citizens in participatory processes that complies entirely to the principles of GEO, transforming GEOSS data into services for the end users.

Space Technology Solution

The project framework includes the creation of a hub, in order to support the development initiatives of regional management structures, providing sectorial applications with regard to multiple sectors of the regional economy. The uniqueness and novelty of the project lies in a) the interconnection and management of data (telemetry, remote sensing and reference data) in a central shell, b) serves spatially focused services to citizens and businesses while following international standards, c) ensures both spatial and thematic extendibility, and d) provides modular architecture.

Implications

The sectorial applications that will be developed, focus on the rational management of natural resources as they are the common basis for the development of primary, secondary and tertiary sectors of the regional economies while the status and their use depends on the quality of the natural environment and quality of life. Moreover, the project has a positive impact on the environment, since the interest is focused on assessing natural hazards, prevention and response to pollution of soil and water resources from the exercise of human activities in rural areas and in the coastal zone. The uniqueness and novelty of the project lies in its compatibility with the international standards of the Group on Earth Observations, United Nations and European Union guidelines, following the approach act local-think global.

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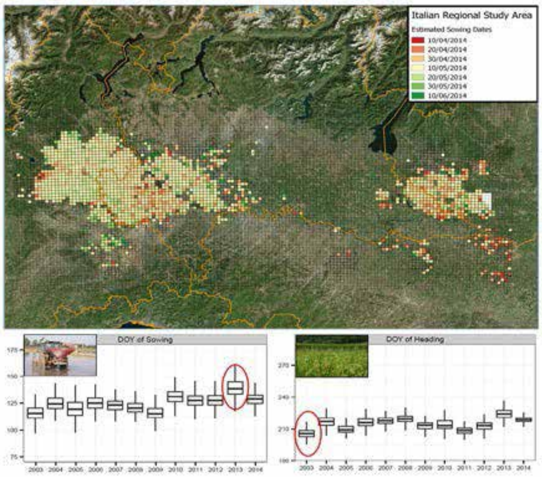
LOMBARDY REGION

EARTH OBSERVATION TECHNOLOGIES FOR RICE CROP MONITORING (ERMES)

ERMES is funded by EU FP7 (2007-2013) under grant agreement n.606983.

The challenge

The agricultural sector is facing important global challenges due to the pressure of food demand, increased price-competition produced by market globalisation and food price volatility (G20 Agriculture Action Plan) and needs of more environmentally and economically sustainable farming. Earth Observation (EO) systems can significantly contribute to these topics by providing reliable real time information on crop distribution, status and seasonal dynamics. ERMES aims to create added-value information for the rice agro- sector by integrating in crop models operational Copernicus core products, maps derived from SAR and optical satellite data processing and in situ observations. Two services will be created for regional authorities and local agro-business.



Estimation of phenological dates from MODIS time series. 2014 sowing map (top panel) and 2003-2014 statisitcs (bottom panel).

Space Technology Solution

ERMES proposes innovative approach for the integration of optical and SAR data in view of fully exploitation of Sentinel missions. Quasi-daily moderate resolution satellite data are used to monitor regional agro-practices, while high resolution Sentinel 1 and Landsat OLI (foreseen Sentinel 2) images are used to detect rice cultivated areas and estimate Leaf Area index (LAI). Smart technologies (mobile app and geoportal) are the basis for in- situ data collection and return of added value information to the users. These added value geo-information are assimilated in the WARM (Water Accounting Rice Model) crop model to estimate daily biotic and abiotic risk and final crop yield.

Implications

The agricultural sector in Europe is facing the challenge to maintain and improve its competitiveness by reducing production costs and minimizing environmental impact of agricultural practices. ERMES services are aiming at supporting regional authorities in the implementation of agro-environmental policies, promoting solutions for sustainable management practices in farming activities and providing independent reliable information to the agro-business sector. The prototype service are developed in Europe with the long-term goal of extending it to Asian and African markets, in order to boost European competitiveness and contribute to sustainable development.

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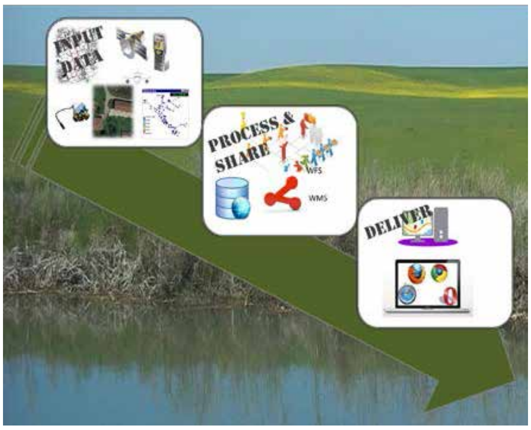
LOMBARDY REGION

SEGUICI - AN INNOVATIVE TOOL TO MANAGE LOCAL WATER PROVISION IN AGRICULTURE AND TO ASSESS THE NEED FOR IRRIGATION

SEGUICI is funded by Lombardy Region and involves three academic institution (Politecnico di Milano, UNIMIB and EUCENTRE), five SMEs (GESP, ANTARES, MMI, ORNI ENG,TERRARIA) and a large enterprise (CGS). The aim is to develop a software platform dedicated to water management for agricultural and civil use. SEGUICI provides an innovative tool to manage local water provision in agriculture and to assess the need for irrigation. The tool relies on hydrological and meteorological models for the soil humidity forecast by means of ground and space data.

The challenge

Future scenario of climate change, combined with limited water resources, require better irrigation management and planning. In dry periods, water scarcity can be amplified by conflicting use of water, e.g. for irrigation, industry and power production. Recently, the need for more efficient water management has been evidenced by water shortages even in those European areas that are usually abundant in water, such as the Po Valley in Lombardy, Italy. Hence comes the need to develop new tools to support managing institutions, water consortia and end users in improving their irrigation schedule, minimizing irrigation costs and saving water. The SEGUICI agricultural application will support real-time moisture conditions monitoring and forecast.



Space Technology Solution

The SEGUICI agricultural application is based on a software that couples meteorological and hydrological models and returns actual and forecasted soil moisture conditions. Besides data from ground stations, satellite data have an additional importance as an input to the predictive model. The meteorological model receives satellite data (e.g. brightness temperature, radiation, cloud coverage) as input parameters. In addition, radar and optical satellite data are used to determine soil roughness, Leaf Area Index, Normalized Difference Vegetation Index, fractional cover and albedo, which enter the hydrogeological model. SEGUICI thus allows the user to visually access straightforward geo-located information on actual and forecasted soil humidity. This allows to estimate the need for irrigation on a local basis (resolution 200m), supporting a more efficient water management improving the irrigation schedule, minimizing irrigation costs and saving water.

Implications

Water saving has a strong impact on the environment. Moreover, efficient water management has beneficial impacts on the society, for it alleviates conflicting use between competing actors. SEGUICI joins competences from agriculture and space and can be a successful example of “cross-fertilization” between different fields.

Acknowledgements

The project is funded by Lombardy Regional in the frame of POR programme 2007- 2013.

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LOMBARDY REGION

SATELLITE EO MEETS HISTORICAL MAPS: GEOPAN ATL@S APP

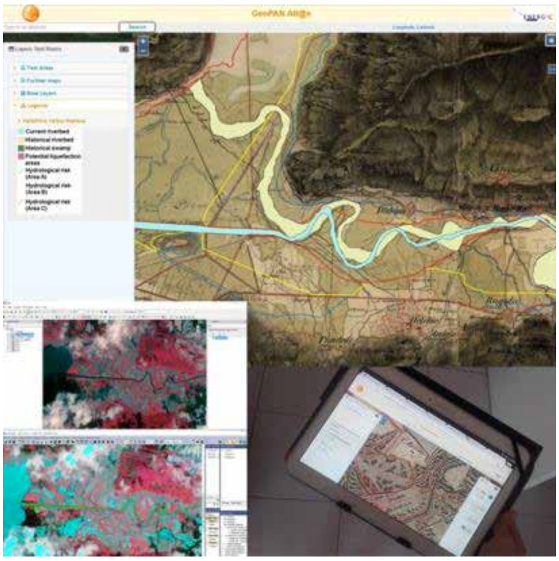
GeoPan Atl@s is one of the 10 Applications of ENERGIC OD Project - European NEtwork for Redistributing Geospatial Information to user Communities - Open Data, coordinated by Italian Research Centre (CNR-IIA). GeoPan Atl@s, developed by Politecnico di Milano, focuses on changes of riverbeds to facilitate the navigation through agricultural landscapes across time and space using multi-temporal and multi-source geospatial Open Data.

Open geo Data at our fingertip

Geospatial Open Data are already in every-day use by citizens. However, there are still some technical and cultural obstacles to be overcome in order to ensure a full uptake and exploitation of Public Sector Information (PSI) by the businesses sector through innovative applications useful to the society.

Interactive APP based on Virtual Hub (VH) approach

From a technical perspective, GeoPan Atl@s is built on the basis of the well-known HTML/CSS/JS structure. In this way GeoPan can be accessed by all browsers supporting HTML5 both from desktop and mobile devices like tablets and smartphones. Using VH approach developed within ENERGIC-OD, GeoPan envisages to facilitate access to open datasets using either a free search or a "profile search" with a definition of a user profile (e.g. a geologist), putting thus the user needs at the center of this interactive process. Thanks to Italian Virtual Hub, GeoPan provides an access to multi-temporal data sets such as historical maps from national archives, analysis of satellite imagery, national and regional geoportals and SDIs, etc.



GeoPan Atl@s APP: Adda Riverbed enhanced upon a historical map (above); thematic layers: NDWI extraction (below left) and OBIA; multi-source data access via GeoPan using a mobile device (below right).

Space for non-Space sectors: innovative APPs for more informed decision making

Several policy communication in Europe could be useful to link geospatial information with management of agricultural landscape such as INSPIRE Directive; Common Agriculture Policy (CAP); Habitat Directive (Natura2000); European Landscape Convention (Florence Convention), to name a few. Putting together historic territorial maps (e.g. cadastre and topographic material) with analysis that derive from Sentinel-2 imagery, GeoPan Atl@s aims to contribute to these initiatives with awareness rising on the changing riverbeds in the area of Lombardy Region (Northern Italy) and on the importance of such features for agriculture purposes in terms of ordinary irrigation but also risk mitigation (e.g. in case of flooding events). Within GeoPan, the user is enabled to geospatially relate, combine and use such data sets, including layers derived from satellite imagery (e.g. riverbed extraction from NDWI and object based classification algorithms) in a faster and user-friendly way, fully demonstrating the geographic coverage potential.

Acknowledgements

The research leading to the results of the application here presented is partially funded under the ICT Policy Support Programme (ICT PSP) as part of the Competitiveness and Innovation Framework Programme by the European Community under the Grant Agreement n°620400.

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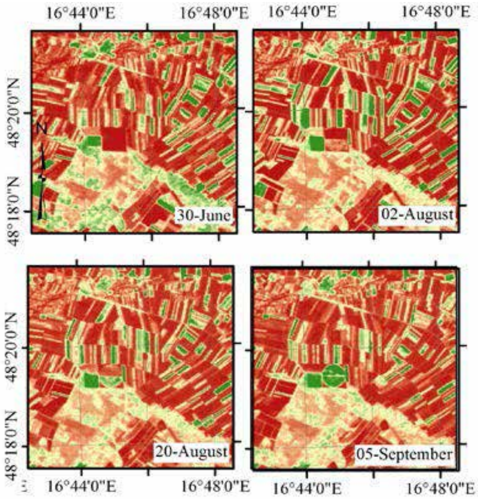
MARCHFELD, LOWER AUSTRIA REGION

INTEGRATION OF LOW AND HIGH SPATIAL RESOLUTION SATELLITE DATA TO PREDICT INTER-YEAR VARIATION OF CROP YIELD A RESEARCH

Project funded by the Austrian Space Applications Programme (ASAP – FFG) to test and demonstrate the transferability of Earth observation technologies for mapping water needs in Marchfeld region, one of the major crop production areas of Lower Austria.

The challenge



Water resource management is a real and tangible issue in this region. Due to the shortage of precipitation and the semi-arid climate, farmers have started to intensify crop production by irrigation with groundwater after the Second World War. Today most of the cultivated land is equipped with irrigation infrastructures. Groundwater is shared with urban and industrial sectors, leading to a high pressure on quantity and quality of resources. Generally, the information available to help in the decision process is based only on agro-meteorological data that does not account for the large spatial variability of crop development, soil conditions and agronomic practices.

Space Technology Solution

The potential of Earth observation techniques to support irrigation water management is nowadays widely recognized: high spatial resolution satellite images are well suited to monitor the crop development and to derive crop evapotranspiration. The methodology is based on the application of the Penman-Monteith equation with weather data from local agro-meteorological stations and crop parameters estimated from satellite acquisitions that are obtained in near real- time and updated once a week. The information is transferred to farmers for irrigation management using webGIS and mobile phone technologies.

Implications

The increased demand for high quality food, sustainability of local production, and market development strategies, is stimulating the application of tools for more efficient water management. The cost-benefit analysis shows that the service would have a cost range between 2.5-4.5 €/ha per year. Irrigation costs range between 400 and 1000 €/ha per year. With a correct irrigation application, more than 10% of the water and energy could be saved in water- intensive crops, which is equivalent to an economic benefit of 40-100 €/ha per year.

Acknowledgements

The authors acknowledge the support from the Austrian Space Applications Programme (ASAP-FFG).

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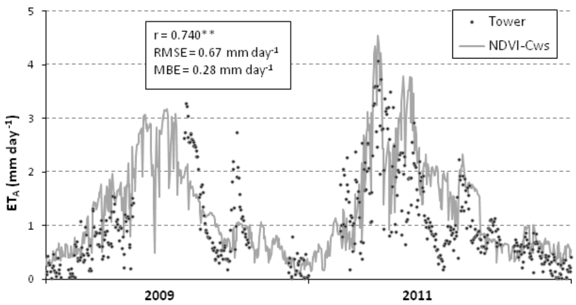
TUSCANY REGION

COMBINATION OF SATELLITE AND ANCILLARY DATA TO MONITOR ACTUAL EVAPOTRANSPIRATION AND WATER STRESS OF MEDITERRANEAN CROPS

Mediterranean crops (wheat, olive, grapevine, etc.) are particularly vulnerable to the water stress episodes which can occur during the growing season (late spring – summer). The images acquired by satellite systems are suited to monitor such phenomena over wide regions, especially when used in combination with various kinds of ancillary data. This has been the subject of several investigations carried out by IBIMET- CNR in the last few years, a summary of which is currently reported.

The challenge

Water stress is a major controlling factor of crop production in arid and semi-arid regions. Actual evapotranspiration (ETA) is a key parameter which indicates crop water conditions and can be estimated by remote sensing observations. Monitoring the ETA annual evolution is therefore essential both for estimating water stress consequences and for planning possible irrigations. Several methods based on satellite observations have been proposed to pursue this task, which can be generally categorized as “energy balance” or “water balance”. Most of these methods, however, suffer from relevant drawbacks which prevent their operational utilization.



ETA measured by an eddy covariance flux tower and simulated by the approach proposed by Maselli et al. (2014) for an annual crop site (Roccarespampani, Central Italy).

Space Technology Solution

An operational water balance method to estimate crop AET has been recently proposed by Maselli et al. (2014). This method, called NDVI-Cws, is based on the combination of NDVI and meteorological data and overcomes most of the problems coming from previous approaches. A full description of the method and its testing in various Italian sites are reported in the same paper.

Implications

Most of developed methods are quasi-operational, i.e. they are virtually ready to be applied in practical cases. These methods, which can work at various spatial scales (regional to local), can identify water stress conditions at a daily time step.

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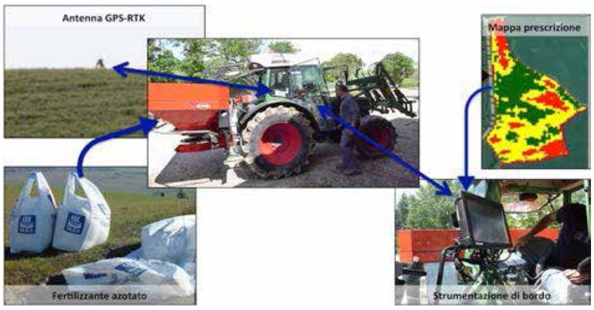
TUSCANY REGION

PRECISION AGRICULTURE FOR PASTA OF TUSCANY GROWERS

"Precision Agriculture for the Pasta of Tuscan Growers" is a project funded by Tuscany Region as part of the Rural Development Program (PSR). The aim of the project is to guide nitrogen fertilization in wheat crop both through agricultural machines equipped with geo-referencing systems and crop monitoring carried out by remote sensing. The partners involved in the project are Department of Agrifood Production and Environmental Sciences – University of Florence, "Consorzio Agrario di Siena" and many farms of Val d'Orcia. It's important to note that the project involved an entire geographic area of Tuscany, not only a single field as usually happens in a similar scientific experiment.

The challenge



This system maximizes the input use efficiency in order to limit environmental, social and economic impacts. An innovative production model was developed and tested in the Val d'Orcia farms. The model is based on the integration between the agronomic knowledge, with modelling, the latest technology for environmental monitoring and spatial localization of agricultural machines. The innovations introduced were:

- machines equipped with GPS systems and remote control system that allows to collect and analyse georeferenced information usable to drive the machines in the field,
- the use of high spatial satellite image (5x5) to obtain information about crop status, biomass quantity, vigour and nitrogen content,
- the innovation applied in Val d'Orcia area to develop a model that can be applied in other wide areas, like the province of Florence, Arezzo and Siena,
- the use of vegetation indices maps to produce prescription maps usable for driving nitrogen fertilization,
- gathering and storing the information in a geodatabase, useful not only for the activity traceability but also to refine more and more the farming activities and the adoption of new production models.

Space Technology Solution

The goal of the project was to acquire large-scale information to develop relationships for deriving the main wheat phenological phases, such as emergency, lifted and flowering, from remote sensing images. For this purpose, images were acquired during the production season at the most relevant phenological phases, anthesys and rising, useful also for managing early intervention in the field.
Moreover, multispectral images in the regions of the visible and infrared were used for the calculation of the vegetation indices.
In this project the commercial satellite used is the Rapid Eye:

- Resolution on the ground: metric (5.0 m);
- Maximum Cloudiness: 20%
- Remotely sensed Area: 3500 km2;
- Acquired bands: Red, Green, Blue, Red and NIR Edge;
- Geo-referenced.

The multispectral data in the visible, infrared and green regions, allow to measure the crop diagnostic behaviours as a response to environmental and agronomic inputs, such as plant morphology, status and health condition.

Implications

Input farming, such as processing, fertilization, pesticide treatments and irrigation, are closely related to productive results, profitability, business competitiveness and to the environmental impact of food production.
Site-specific applications consent to calibrate the application on the actual crop need, as a function of the physical environment variability and the plant production response. This approach leads to an increase of the efficiency in the use of inputs hence reducing both the waste due to high amounts of external-inputs influencing positively on the farm economic balance.
For the administration of the varying doses, a thorough monitoring is required. Therefore, soil, crop and climate should be monitored over large tracts with a high spatial resolution. That's the only way for having the awareness of the variability of each cultivated field.

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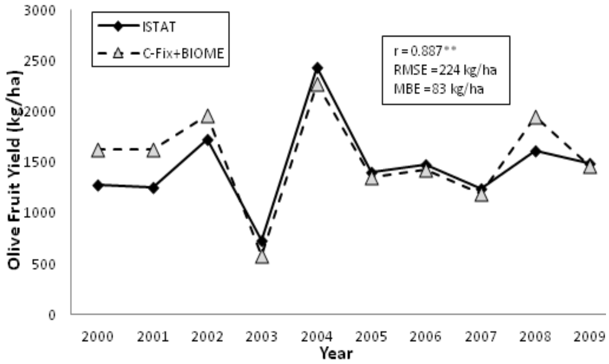
TUSCANY REGION

INTEGRATION OF LOW AND HIGH SPATIAL RESOLUTION SATELLITE DATA TO PREDICT INTER-YEAR VARIATION OF CROP YIELD

Existing and foreseen satellite systems are useful for monitoring crop condition and predicting crop yield at various spatial and temporal scales. IBIMET-CNR has developed semi-operational methods to follow the seasonal evolution of main crops and predict their yields based on various satellite sensor data (Landsat-TM/ETM+, Terra/Aqua-MODIS, etc.). The potential of these methods in representative case studies is briefly described.

The challenge

Predicting inter-annual variations of crop yield over wide regions is important for several practical purposes. This is true both for annual crops such as wheat, corn, barley, etc. and for perennial cultivations, such as olive groves and vine yards. Remote sensing data taken from satellite platforms are particularly suitable to assess crop conditions over wide areas. None of the existing satellite sensors, however, have the spatial and temporal resolutions needed to monitor crop conditions over the fragmented landscapes which are common in European areas.



Olive fruit yield of Tuscany derived from ISTAT statistics and obtained by the simulation approach described in Maselli et al., (2012).

Space Technology Solution

The previously exposed challenge requires the development of methods to integrate data from different sensors, such as Landsat-TM/ETM+ and Terra/Aqua-MODIS. This subject has been widely investigated by the research group of IBIMET-CNR, which has published a large number of scientific articles. These papers describe advanced methods to integrate NDVI data with different spatial and temporal features in order to feed a parametric model (Modified C-Fix) in predicting the yield of most important crops (wheat, olive, etc.).

Implications

Most of developed methods are quasi-operational, i.e. they are virtually ready to be applied in practical cases. These methods can work at various spatial scales (regional to local) generally using a daily time step and predicting crop yield with an anticipation around one month.

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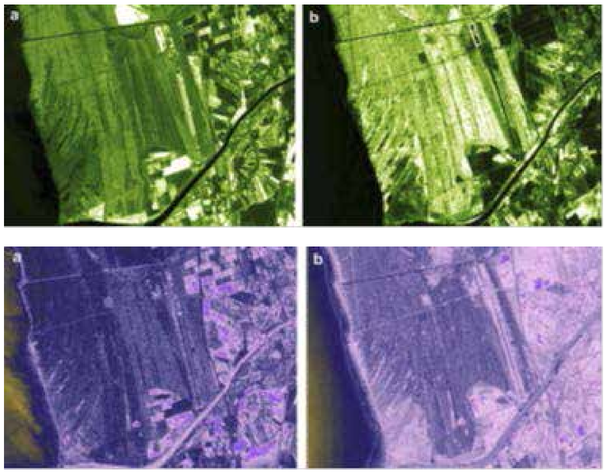
TUSCANY REGION

SPACE TECHNOLOGIES FOR CROP MONITORING: ASSIMILATION OF BIO-PHYSICAL AND BIOCHEMICAL VARIABLES IN BIOCHEMICAL AND HYDROLOGICAL MODELS AT LANDSCAPE SCALE

ESA Category-1 LBR PROBA/CHRIS Project ID 2832: “Assimilation of biophysical and biochemical variables in biochemical and hydrological models at landscape scale”

The challenge

Monitoring relevant changes of forestry, crops and seasonal wetland areas at regional scale in Tuscany region by means of remote sensed biophysical and biochemical variables.



NDVI (up) and PRI (down) images computed for the CHRIS acquisitions on: (a) 27 March 2004 and (b) on 8 September 2004.

Space Technology Solution

Since 1993 San Rossore (Pisa, Italy) has been utilised by the “Nello Carrara” Applied Physics Institute (IFAC) of the Italian National Research Council (CNR) as a permanent test site for aerospace campaigns. Since 2003 San Rossore has been also utilised as an additional forestry test site in the frame of the CHRIS / PROBA-1 AO Proposal: “Assimilation of biophysical and biochemical variables in biochemical and hydrological models at landscape scale”. CHRIS is a hyperspectral imager that is able to perform multi-angular acquisitions of the same scene. Such characteristics allowed, through the BRDF assessment, the retrieval of relevant parameter for the determination of forestry and agricultural productivity, such as GPP, LAI and so on. The availability of long time series of remote sensed images of the same area permits the monitoring of change in the land use of the observed scene.
From a technological point of view the CHRIS/Proba-1 mission features a sensor that is mounted on a satellite featuring pointing capability.

Implications

Significant changes in the land use of the territory, as well as monitoring of the effect of natural disasters such as flooding and land-slides, could be monitored by the use of routine hyperspectral data acquisitions.

Acknowledgements

The authors wish to acknowledge ESA and Surrey Satellites for routine data acquisitions on San Rossore test site.

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TUSCANY REGION

SPACE TECHNOLOGIES FOR CROP MONITORING

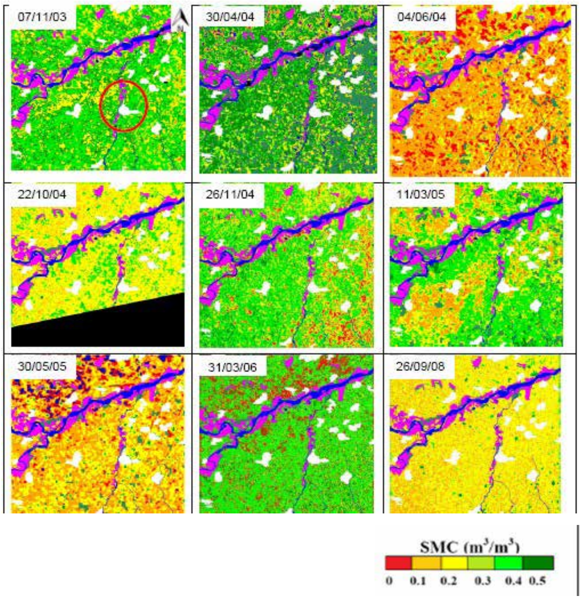
NOWCASTING – ASI project devoted to the civil protection from floods from space (ENVISAT and Cosmo-SkyMed)
HYDROCOSMO – ASI project for investigating the hydrological cycle by means of satellite data (Cosmo-SkyMed)
GRASS – ESA project for monitoring vegetation biomass using GNSS-R signal at L band
CATARSI – ASI project for monitoring agricultural crops and forests using P, L and X band SAR images

The challenge

Climate changes are causing a worsening in natural phenomena by increasing the strength (intensity) and the duration of rainfall, heat waves, and drought. This led to an increase in natural hazards such as fires, floods, avalanches, landslides.

Space Technology Solution

The use of EO data allows a continuous monitoring of the Earth surface and thanks to the increased spatial resolution and revisit time of many satellites a detailed surveillance of many risk areas.
Many Italian and European projects (see the list above) have been and are still devoted to this goal by using SAR images.
at L, C and X bands and more innovative sensors such as GNSS-R. The radar signal at different frequencies can be related to most parameters of the hydrological cycle, allowing the implementation of algorithms able to generate multi-temporal maps of these parameters (vegetation biomass, soil moisture, snow cover and depth).



Soil Moisture Content Maps in Alessandria area (Piedmont Region, Italy) obtained from SAR C data.

Implications

The output of this research has a positive impact of regional policies allowing a better monitoring of the environment, the forecast of many natural events and their management, as well as a more accurate estimate of the damages and rapid identification of possible solutions.

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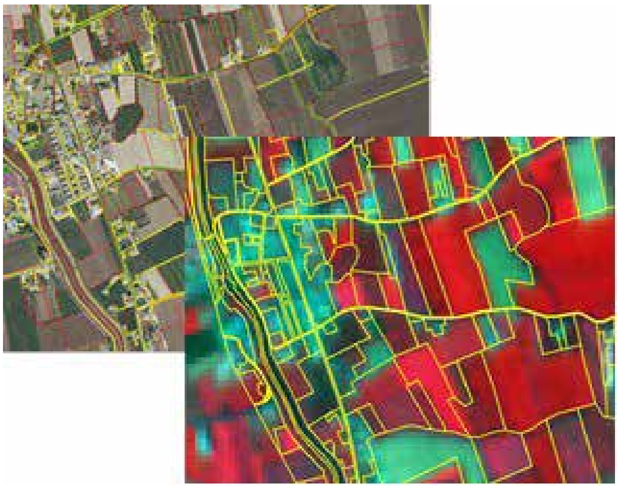
VENETO REGION

A DECISION SUPPORT SYSTEM FOR WATER RESOURCE MANAGEMENT IN THE AGRICULTURE SECTOR

An integrated solution for the optimization of water resources management in agricultural areas. The DSS is based on remote sensing techniques, mathematical modelling and geographical information systems.

The challenge



In March 2005 Veneto Region began a project within GMES now Copernicus for the creation of a Land Cover Map. After this first step Veneto Region ha developed procedures for the analysis and the methodologies for the realization of the Land Cover Map for the entire Region. The Map was published in two editions during the 2009 and 2015.
Subsequently to this project Corvallis S.pA. using the experience and the output of the Land Cover Map of Veneto began a new project for the optimization of the water resource management in agriculture areas for a consortium in the Veneto plain. The main challenge of the application was the development of a DSS for the quantification of real water requirements of each agricultural plot. The results could be visualized at different scale of representation: from the single plot to the entire study area (20.000 hectares) located in Veneto plain.

Space Technology Solution

Multispectral time-series of LANDSAT ETM+ (Enhanced Thematic Mapper Plus) satellite images, acquired in the same season, were used to discriminate the different annual crops (corn, wheat, barley, soya, sunflower, tobacco, ecc.).
An accurate agricultural land cover map was realized on images classification. The implemented methodology allowed an accurate identification of the main annual crops (95% of overall accuracy calculated on ground test samples).

Implications

The DSS software allows the determination of water balance of the soil in relation to meteorological data, soil type and annual crops. The developed solution helped the manager of water resources to define the volumes of water required to complete the phonological cycle of the crops in a specific area.

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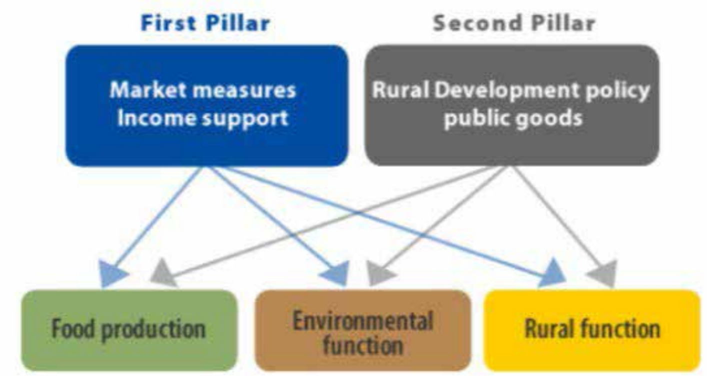
ANNEX II - European Common Agriculture Policy (CAP)

Europe's Common Agriculture is undoubtedly one of the most significant and established instruments of the European Union. As reported by EC, CAP has existed since the end of the 1950's. Since then, different states that made up the European Union sought to establish a common framework for agriculture activities in order to organize and revitalize the economies that were severely damaged after two world wars. The CAP strives to organize and systemize all agriculture policies of Member States (MS) as well as to generate large quantities of subsidies and investments that can stimulate the agriculture industry.

It is estimated that the CAP amounts to almost half of the total budget of the European Union which means that CAP funding is around 50 billion Euros per year. It is important to note that this is the only industry within the economy for which EU MS have transferred their policy and regulatory autonomy to the European Union, to such a degree that said EU establishes and sets the overall framework, while leaving the responsibility of its implementation to MS, which must then respond responsibly. The EU leaves MS with only a limited field of specific application for minor issues.



Graphic Illustration of Common Agriculture Policy: main pillars (source rural Development gateway.)

The CAP is divided into two "pillars": **(1) production support and (2) rural development**. The essential rules governing rural development policy, as well as the policy measures available to MS and regions, are focused on **three thematic axis**:

- Axis 1 - improving the competitiveness of the agricultural and forestry sector;
- Axis 2 - improving the environment and the countryside;
- Axis 3 - improving the quality of life in rural areas and diversification of the rural economy.

The Common Agriculture Policy (CAP) has undergone substantial reform since the early 1990s, reflecting changing societal demands and political priorities. Agro-environment measures are a key element for the integration of environmental concerns into the CAP. Sustainable agriculture both promotes and is enhanced by biodiversity, which is the basis of agriculture and has enabled farming systems to evolve ever since agriculture was first developed. Biodiversity is also the foundation of ecosystem services essential to sustain agriculture.

The European Union has set the target of halting the loss of biological diversity by the year 2020, after having failed to meet this goal by 2010. Agriculture, because of its large proportion of land use (41 % in the EU) plays a decisive role for the state of the environment and for the implementation of biodiversity goals in Europe. A CAP compatible with nature and taking account of ecological efficiency was afforded great significance thus a framework reform of the CAP for 2014-2020 was prepared since 2010. The new CAP maintains the two pillars, but increases the links between them, thus offering a more holistic and integrated approach to policy support. As a result it is adapted to meet the challenges ahead by being more efficient and contributing to a more competitive and sustainable EU agriculture. In short, EU agriculture needs to attain higher levels of production of safe and quality food, while preserving the natural resources that agricultural productivity depends upon. Therefore, a new policy instrument of the first pillar (greening) is directed to the provision of environmental public goods, which constitutes a major change in the new CAP policy framework. In this way, farmers should be rewarded for the services they deliver to the wider public, such as landscapes, farmland biodiversity and climate stability, even though they have no market value.

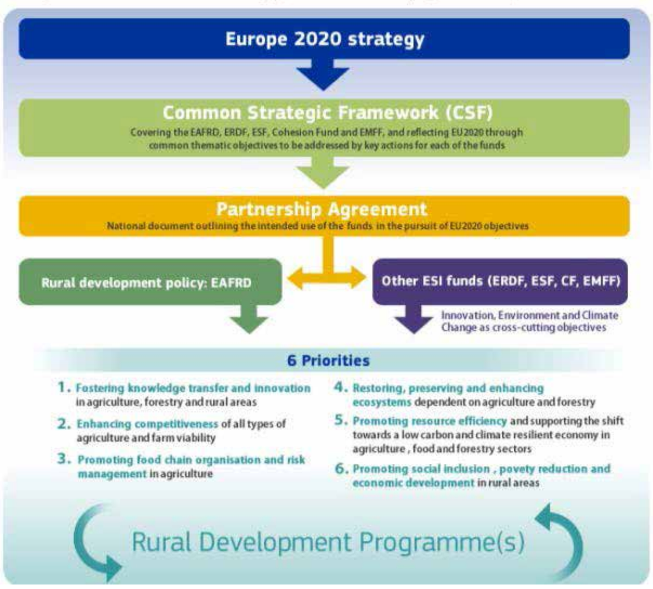
The main axis of CAP concerning support programmes with relevance for environmental protection is Axis 2, where agri-environment measures are one of 13 topics under this Axis in Pillar II. These measures are intended to ensure the delivery of ecosystem services in rural areas, including in areas with physical and natural handicaps, and preserving land management. Agri-environment measures display a variety of programmes in different MS across Europe. The baseline is laid down in Regulation EC 1698/05, where article 39 states that monetary support may be given to farmers who voluntarily take on commitments going beyond mandatory EU and national regulation. Agri-environment measures are diverse, but broadly speaking, one could say that each measure has at least one of two broad objectives: reducing environmental risks associated with modern farming on the one hand, and preserving nature and cultivated landscapes on the other. These measures may be designed at national, regional or local level so that they can be adapted to the particular farming systems and environmental conditions, which vary greatly throughout the EU. This makes agri-environment a potentially precise tool for achieving environmental goals.

Source of information of this section: official website of the European Commission on Agriculture and Rural Development accessed via http://ec.europa.eu/agriculture/index_en.htm

ANNEX III - Rural development 2014-2020

The European policy framework for rural development can be divided into four levels, namely: (i) European strategic guidelines; ii) National strategies; (iii) Programmes ; and (iv) Detailed implementation by thematic axis and measure.

This structure provides a common framework for individual Member State planning and programming, guided by the EU Strategic Guidelines. The aim is that, within the common EU guidelines, MS and where appropriate regions, develop plans which are tailored to the meet their own specificities and challenges. The framework includes planning documents at each level which articulate rural development strategic priorities, detailed programmes and individual rural development measures selected to respond to the rural development needs in a specific country and/or region. As in the past, during the new programming period (2014-2020) the Rural Development Policy will be implemented through national and/ or regional rural development programmes (RDPs) which run for seven years. MS will have to build their RDPs based upon at least four of the six common EU priorities.



Policy Overview 2014-2020 (source Rural Development Gateway)

Rural Development Programmes (RDPs) are instruments used by the Member State to implement their rural development policy. A Member State may have either a single programme for its entire territory or a set of regional programmes. The rural development policy framework offers a 'menu' of 41 measures from which MS can choose those that suit the needs of their rural areas best. These are then included in their national or regional programmes. The EU contribution to the financing of measures depends on the measure and the region concerned. For more details on RDP measures, see Council Regulation (EC) No 1698/2005 of 20 September 2005 (support for rural development by the European Agricultural Fund for Rural Development (EAFRD).

Individual measures by Axis are the following:

- Axis 1 - Improving the competitiveness of the agricultural and forestry sector
- Axis 2 - Improving the environment and the countryside
- Axis 3 - The quality of life in rural areas and diversification of the rural economy
- Axis 4 - LEADER (a particular form of methodological approach aimed at ensuring wide participation in the identification of priorities to be addressed within a limited territory and homogeneous and consequent definition of the decisions and strategies to be implemented)

Source of information of this section: official website of the European Commission on Rural Development Gateway 2014-2020 accessed via http://enrd.ec.europa.eu/en/policy-in-action/cap-towards-2020/rdp-programming-2014-2020

ANNEX IV - Glossary

Agriculture - farming and livestock including all activities directly related to them such as shipping, processing and preservation of agriculture products.

Agriculture product - a product of agricultural activities (Agriculture), of which some examples are cereals such as wheat, corn, vegetables such as potatoes and carrots or fruits such as strawberries and apples, etc. All of these are products of agricultural activities while they are used largely as foods, although they can also be used in several industries (fragrances, clothing, hygiene, etc.).

Agriculture production levels - variables that must be considered by several parties involved when determining investments, production margins or profits. Furthermore, agriculture production must be appropriately controlled and organized using knowledge of the cycles of nature and those of the products being cultivated, along with climate factors which can often cause the loss of years of labour. Other elements that must be considered include storage, processing or shipping of obtained products in adequate conditions in order to avoid spoilage. Lastly, in order to achieve profitable agriculture production, regulations must allow the recovery of investments along with some sort of profit for the businessman.

Common Agriculture Policy (CAP) - The main goals of CAP are to increase agriculture productivity by promoting technical progress and safeguard the workforce, to improve living standards of farmers and producers of agricultural products, to stabilize markets, to maintain an ample reserve of foodstuffs and to develop and establish logical, reasonable prices for consumers. In this manner, once the objectives and interests of EU MS were established under the coordination of the European Union, the basic drivers became the stimulation of the agriculture industry's productivity by way of subsidies, job security for rural workforces and EU budget increases for this sector of the economy. What was sought was to establish a predictable and stable environment for all players involved, most importantly for producers, but also for consumers and all participants in the food industry's value chain. Throughout its history, the CAP has encountered numerous reforms related to changing circumstances present at each point in time. To this day, this policy still maintains the agriculture industry with one of the highest levels of investment in Europe.

European Innovation Partnerships (EIPs) - act across the whole research and innovation chain, bringing together all relevant actors at EU, national and regional levels in order to: (i) step up research and development efforts; (ii) coordinate investments in demonstration and pilots; (iii) anticipate and fast- track any necessary regulation and standards; and (iv) mobilise 'demand' in particular through better coordinated public procurement to ensure that any breakthroughs are quickly brought to market. Rather than taking the above steps independently, as is currently the case, the aim of the EIPs is to design and implement them in parallel to cut lead times.

EIPs streamline, simplify and better coordinate existing instruments and initiatives and complement them with new actions where necessary. This should make it easier for partners to co-operate and achieve better and faster results compared to what exists already. Therefore, they build upon relevant existing tools and actions and, where this makes sense, they integrate them into a single coherent policy framework. Flexibility is important; there is not a 'one-size-fits-all' framework.

European Network for Rural Development (ENRD) is the hub that connects rural development stakeholders throughout the European Union (EU). Discover how the ENRD is contributing to the effective implementation of MS' Rural Development Programmes by generating and sharing knowledge, as well as through facilitating information exchange and cooperation across rural Europe.

European Network for Rural Development Gateway provides a bridge between the 2007-2013 and the 2014-2020 programming periods. It builds upon current experiences and knowledge with a view to guide the design and the implementation of the future rural development programmes. From RDP design to implementation, delve into specific policy areas and stay up-to-date with the latest news and views from the rural development community.

LEADER Approach - Started in the late '80s, the Community Initiative Leader has introduced and developed over the years a Local programming method characterized by a "bottom", multi-sectoral, integrated and innovative in the definition of local development strategies. Besides these features, the "Leader method" includes as an additional qualifying element: the realization of projects of cooperation and connection network between the local partnerships. The Leader approach, therefore, promotes and supports rural development projects designed and shared at the local level in order to revitalize the area, create jobs and improve the general living conditions of the rural areas. Since 2007, the Leader approach has become part of the tools provided by the Rural Development Programme and is one of the axes proposed by the EC Regulation 1698/2005 to support the development of rural areas (Axis 4). Axis four is different to the other three axes, being defined by the use of the Leader methodology rather than by a given theme. The scope of Leader operations varies very considerable between MS. It comprises Competitiveness, Environment/land management, Quality of life/diversification, Implementing cooperation projects and Running the local action group, skills acquisition, animation.

Rural Development Policy (RDP) – in order to achieve a balanced approach to policy, MS and regions are obliged to spread their rural development funding between all three of these thematic axes. The intention is to ensure that each national programme reflects the three main policy objectives (viable food production, sustainable management of natural resources and climate action and balanced territorial development), while leaving a high margin of flexibility for governments to emphasize the policy axis they wish.

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