

## COMBINED EXPLOITATION OF SINO EU EARTH OBSERVATION DATA FOR SUPPORTING THE MONITORING AND MANAGEMENT OF AGRICULTURAL RESOURCES

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### List of Principal Investigators (PIs)

Topic Nr.	PIs	Title
32275_1	Prof. Raffaele Casa, Prof. Guijun Yang	<b>Algorithm Development Exploiting Multitemporal and multisensor Satellite data for improving crop classification, biophysical and agronomic variables retrieval and yield prediction (ADEMS)</b>
32275_2	Prof. Giovanni Laneve, Prof. Wenjiang Huang	<b>Assimilating multi-source earth observation satellite data for crop pests and diseases monitoring and forecasting (AMEOS)</b>

### EXECUTIVE SUMMARY

Following the successful experience of the past Dragon 3 project (ID10488) and the Dragon 4 recommendations, the current proposal encompasses two Topics pertaining to the Agriculture, food & water Research Theme i.e.: i) Wet and dry land crops mapping, retrievals & yield prediction and ii) Food security. The main common feature of the research activities proposed for both topics is the emphasis on the assimilation of multi-sensor and multi-temporal EO into agricultural crop models, with the aim of expanding the current capability of monitoring relevant variables and processes for the two topics. Complex agricultural crop models comprise a large array of biophysical and physiological processes so that novel approaches and algorithms are needed to optimize the contribution of Earth Observation (EO) data to the monitoring capability. The project will aim to maximize the benefit of combining ESA and NCRSS EO data to extend the current exploitation capability in agriculture, for example by developing and validating algorithms to improve crop biophysical and soil key variables retrieval from optical and SAR data, to assess crop growth processes and pathogens potential diffusion information, to improve the prediction of crop yield from farm to regional scale. The general project objective is to maximize the synergy in the use of ESA (Sentinel 1/2), ASI (CSK, PRISMA), and Chinese (HJ, GF) sensors data to study and monitor agricultural processes occurring in farmland areas, targeting crop production issues both at the local and regional scale. The project aims to provide tools useful to monitor the sustainability of agricultural systems in different environments and the impact of climatic change on agricultural systems productivity. The specific objectives can be summarized in the exploitation of the new radar and optical EO data: The outcomes of the project will help to decrease the scope and extent of vector-borne diseases, and improve prevention & control capabilities to vector-borne diseases. Additionally, the research results can be used to assess environmental characteristics around the sites of major infrastructure and facilities, and provide the suggestion on site selection and implementation of infrastructures. The synthetic feature extraction techniques developed for multi-source multi-level remote sensing data can also be applied to other service fields, sustainably making contribution to knowledge within the communities. assess the effect of biotic and abiotic stress on the loss production. In particular, project deliverables will be: i) advanced remote sensing methods for cereal crop bio-physical parameters characterization; ii) spectral recognition models for diseases and pests on cereals iii) innovative crop yield estimation (loss) method by using suitable crop model, iv) models with high versatility for diseases and pests predicting assimilating multi-source remote sensing data and meteorological data with mechanisms of diseases and pests prevalence; v) Academic lectures and scientific papers. To assure to fulfill the project objectives a significant multiyear funding source is available for this project. Specifically, not considering the future funding possibilities that the single Institution or the consortium can acquire, at present the project funding is assured until the first semester of 2020 (by adding all the resources at present established by EU and Chinese partners) with a total budget of 835K€. The budget is derived by FP7 EU projects, National Space Agency and National projects. The complete and detailed list of funding is reported in the paragraphs describing the topic activities.

**ABSTRACT 32275\_1: "Algorithm Development Exploiting Multitemporal and multisensor Satellite data for improving crop classification, biophysical and agronomic variables retrieval and yield prediction (ADEMS)"**

**European Principal Investigator**

Prof. Raffaele Casa  
 (University of Tuscia, ITALY)

**Chinese Principal Investigator**

Prof. Guijun Yang  
 (National Engineering Research Center for Information  
 Technology in Agriculture (NERCITA), China, CHINA)

The goal of this proposal is the development and improvement of algorithms exploiting multi-temporal and multi-sensor satellite data assimilation into crop models. An unprecedented frequency of high spatial resolution data can be obtained by combining European and Chinese satellite acquisitions. This calls for the development of specific data assimilation approaches addressing the issue of the multi-scale and multivariate nature of these data. There are several methodological problems, e.g. the assessment of errors and uncertainties in the remote sensing observations, in crop models and parameters. The project will address these aspects thanks to a truly multidisciplinary team with competences ranging from optical to radar remote sensing, crop modeling and agronomy. The project will have a core validation WP based on well-equipped test sites in Europe and China. The Specific Objectives (SO) are:

SO1. Improvement of crop classification approaches

Development of classification algorithms based on multitemporal optical and radar data allowing the incorporation of cropping systems dynamics information.

SO2. Crop biophysical and soil variables retrieval from optical and SAR data

Development of algorithms exploiting the potential of multi-temporal remote sensing data in retrieving vegetation canopy biophysical variables, i.e. including a priori knowledge on the dynamics of these variables. Methods will be developed for the exploitation of the synergy in the use of optical and microwave remote sensing data, in particular: ESA (Sentinel 1/2), ASI (CSK, PRISMA), and Chinese (HJ, GF) sensors. Soil variables, e.g. soil moisture and texture will be targeted using SAR and optical (SWIR) data.

SO3. Defining errors and uncertainties in remote sensing variables and crop models processes and parameters

Specific focus of the project on the investigation of the optimal way to incorporate, into assimilation algorithms, uncertainties and errors in the remote sensing observations, in the retrieval of biophysical variables and in the crop models. This will include the examination of formulation errors inherent in process-based crop models of different complexity and of the uncertainty on model parameters and driving input variables. Global sensitivity analysis and observing system simulation experiments will be used to compare models and configuration choices.

SO4. Data assimilation of multivariate and multi-scale remotely sensed variables into crop models

Since the assimilation of more than one variable can lead to improved results, the project will focus on the development of multivariate and multiscale assimilation approaches. Variables to be assimilated will include leaf area index (LAI), variables linked to crop N status and soil moisture. The assimilation algorithms will be mainly based on Ensemble Kalman Filter (EnKF) and Particle Swarm Optimisation (PSO) methods on which the consortium members have expertise.

SO5. Crop yield and quality estimation under abiotic stress factors at the farm and regional scale

A specific target of the assimilation activity will be the estimation of crop yield and quality as affected by abiotic stress factors such as drought or temperature extremes. Specific validation activities will be carried out both at the field and at the regional scale.

This project will be funded by

(1) Spectral monitoring of wheat growth indicator, Ministry of Agriculture, 2013-2017, 850,000 RMB, PI: Prof Guijun Yang

(2) Double-scale crop nitrogen prediction based on assimilation of crop growth model and remote sensing data, the NCFS programme, 2015-2018, 800,000 RMB, PI: Prof Chunjiang Zhao

(3) FP7 ERMES: European Commission, 2014-2017, (Grant Agreement nr. 606983) 169,000 Euros, Dr. Stefano Pignatti

(4) Exploring the potential for precision nutrient management in China, the UK STFC Newton Agri-Tech Fund, 2015-2016, 375,000 GBP, PI: Prof Zhenhong Li

**ABSTRACT 32275\_2: “Assimilating multi-source earth observation satellite data for crop pests and diseases monitoring and forecasting (AMEOS)”**

***European Principal Investigator***

Prof. Giovanni Laneve  
 (University of Rome, ITALY)

***Chinese Principal Investigator***

Prof. Wenjiang Huang  
 (Institute of Remote Sensing and Digital Earth,  
 China, CHINA)

This project aims to bring together cutting edge research to provide pest and disease monitoring and forecast information, integrating multi-source information (Earth Observation-EO, meteorological, entomological and plant pathological, etc.) to support decision making in the sustainable management of insect pests and diseases in agriculture. The main objective of this project is to ensure food security by improving crop diseases and pests monitoring and forecasting and proving these information to policy makers. This will be achieved through utilization of EO data, the development of new algorithms, and the fusion of new and existing data from multi-source EO sensors to produce high spatial and temporal land surface information. The project will explore the fusion of novel data sources from new and existing satellite sensors (e.g. GF series, ZY-3, HJ, CHRIS, SENTINEL-1/2/3, Cosmo-SkyMed and Landsat-8) to overcome spatial and temporal deficiencies in individual data. Approaches for better estimation of high resolution surface temperature statistics, diurnal surface temperature patterns, Surface Soil Moisture (SSM) and vegetation dynamics will be investigated. In addition, the consortium will validate and prove the relevance of these data products to existing disease development models: a plant pathogen (wheat stripe rust) and an insect pest (maize ostrinia nubilalis), and its associated biopesticide/pesticide. These pathogen models aim to estimate the rate of pests and diseases progression using the EO data products developed during the project to give outputs such as speed of kill of the pest/disease when a biopesticide/pesticide is applied, and how fast the pathogen is developing in the field, under given conditions. The team will also validate and prove the relevance of these models and data products through field experiments. Models will be validated in the laboratory and in the field to give a measure of certainty of predictions. Subsequently, to produce an estimation of risk and potential yield losses, the team will explore their application to existing wheat rust and powdery mildew pesticide models and maize ostrinia nubilalis biopesticide models. The project team will also explore the possibility of using available satellite images datasets to assess the evolution of diseases on permanent crops (olive groves, vineyards), for example, the spread of phytosanitary threats as the Xylella fastidiosa (olive groves) or fungal trunk diseases (vineyards) in Italy.

To ensure the project outcomes will have the greatest impact, a dissemination system will be established as a platform to deliver pests and diseases monitoring and forecasting information in China and Italy. This will facilitate the adoption of our research achievements by both the government and the farmers, thus reduce the impact of yield loss caused by crop pests and diseases. The project aims to continue a successful collaboration building on previous experience from the previous Dragon projects and continue to strengthen the collaboration between project partners in Italy, UK and China. The consortium also aims to extend the impact of the project work through publication in high impact factor open access publications and attending international conferences.

As regards to co-funding of this activity, the Chinese PI, Wenjiang Huang, has two projects as co-fund to run this project: 1) Study of spectral diagnosis mechanism and methodology on carotenoid detection of crop nutrient stress; a 4y project (2016-19) co-funded (41571354) by National Natural Science Foundation of China for 956KY; 2) The external coop. program of BIC; a 3y project (2015-18) co-funded (131211KYSB20150034) by CAS for 1000 KY, while the EU PI, Giovanni Laneve, has one project as co-fund to run this project titled “Developing a classification method for periodically updating of agricultural maps in Kenya”; a 3y project (2015-17) co-funded (2013-078-C.0) by Italian Space Agency for 270 K€.