APPLICATIONS FOR PRECISION AGRICULTURE: THE ITALIAN EXPERIENCE OF SIRIUS PROJECT

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ABSTRACT

This paper reports the results of the project SIRIUS (Sustainable Irrigation water management and River-basin governance: Implementing User-driven Services) for the pilot area located in Southern Italy. SIRIUS is a research project funded by EU FP7 in the Global Monitoring for Environment and Security (GMES) framework supporting the development of monitoring services through remote sensing and ICT technologies to deliver the service to the final users. SIRIUS is developing efficient water resource management services in support of food production in water-scarce environments. It addresses water governance and management in accordance with the vision of bridging and integrating sustainable development and economic competitiveness. The project is developing new services for water managers and food producers, and a range of additional information products in support of sustainable irrigation water use and management under conditions of water scarcity and drought. The aim of this paper is to describe the Earth observation dataset for the Italian pilot area and its use within the decision support system (DSS) SPIDER (System of Participatory Information, Decision-Support and Expert Knowledge for irrigation and River-basin water management). SPIDER is based on open-source software to produce maps of the irrigation requirements of crops with different scales (from a single farm, field irrigation district to the entire watershed).

Keywords: water framework directive, irrigation; remote sensing; precision farming, water

BACKGROUND AN OBJECTIVE

[1]In Future scenarios are expected to be worse due to climate change that might intensify problems of water scarcity and irrigation requirements in the Mediterranean region (IPCC 2007, Goubanova and Li 2006, Rodriguez Diaz et al.

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[1] The paper is a common work of the authors. In particular, Altobelli wrote 1; Nino P. wrote Sections 3.1; Vuolo wrote Section 4. Sections 1 and 5 are a common work of the authors.
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2007). The use of water for food production is the largest market share among all other uses and its demand is continuously increasing with population growth (EEA Report No 2/2009).

Historically, irrigation represents between 70 and 80 per cent of all water uses, with some countries using 90 percent or more for irrigation. This percentage is changing as more and more countries face water shortages. It is estimated that over 1 billion people now live in countries and regions where there is insufficient water to meet food and other material needs. By 2030, over 60 percent of the population will live in urban areas (UN, 2004), claiming an increasing share of water abstraction.

Irrigated agriculture is currently facing various issues in relation to the management of the water at basin level. In fact, the number of conflicts between competing uses is rapidly growing, particularly after the sequence of relatively dry years that occurred during then 1990s, and which is expected to continue (or even worsen), given the long running trend in competition for water use (Randall,1981).

addition, the legal framework in the EU is today faced with the new Water Framework Directive (WFD) (60/2000). The introduction of the WFD could bring major changes for irrigated farming in the European Union, particularly as a consequence of the principles of (full) cost recovery, the Polluter Pays Principle (PPP) and the use of pricing of water as a recommended instrument for reducing water use and water pollution (Bazzani *et al*., 2003).

The objective of this paper is to present the “Sustainable Irrigation water management and River-basin governance: Implementing User-driven Services” (SIRIUS) project, which was funded under the 7th Framework Programme of the European Union (EU), and its preliminary outputs for Italian pilot area.

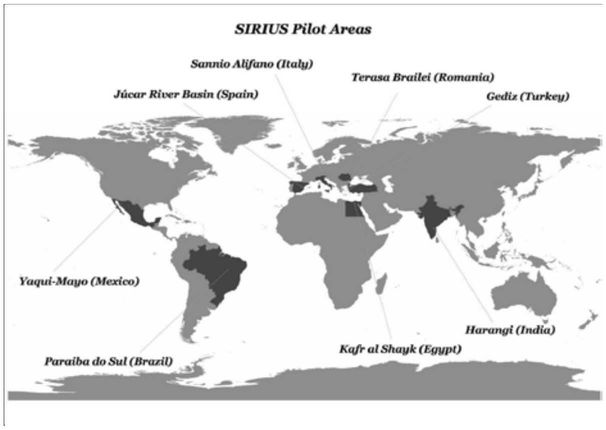
In Section 2, a short presentation of the project is provided, followed by an introduction to water and agriculture in Italy in Section 3. Section 4 provides a description of the methodology, while in Section 5 outcomes of the project.

The SIRIUS project

SIRIUS aims to introduce innovative water management tools for supporting sustainable agriculture and promoting efficient irrigation management practices both at farm level and water basin scale.

The project partnership consists of 18 public and private institutions widespread around the world. The study and analysis is carried out in eight pilot areas that are also the eight case studies of the project. The areas are located in Spain, Italy, Romania, Turkey, Egypt, India, Mexico and Brazil. This paper is about the Italian pilot area located in the Campania region (Southern Italy).

Figure 1 - SIRIUS pilot areas in the world



Source: SIRIUS project

Irrigation and Agriculture in Italy

Generally, Italy is considered to have a good availability in water resources. However, there are large difference between regions due to geographical and climatological circumstances such as (i) unequal distribution of the rainfalls and (ii) irregularity of water flow.

A reduction of water availability was for instance observed in Northern Italy, historically characterized by abundant water resources.

In Italy about 50% of the water available is consumed by agriculture and irrigation is the main water consumer. The largest fraction of the water used by agriculture is derived from rivers (around 66%). In 2007 irrigated land was around 21% of the total agricultural area. Irrigated lands have been 2.666.205 Ha, with 1.694.452 Ha in North, 182.347 Ha in Center and 789.406 Ha in South of the country (ISTAT, 2007).

Due to the current situation, it seems an imperative to support efficient management of irrigation.

Italian pilot area

The "*Consorzio di Bonifica Sannio Alifano*" is located in Southern Italy, North of the Campania region. The administrative area measures 112,982 hectares. The total area utilized for agriculture is 66, 189 hectares that represents the 58% of the total administrative area. Irrigation infrastructures cover an area of 14,070 Ha (21 % of utilized agricultural area) and the irrigated surface measures 10,735 Ha (76 % of the area served by irrigation infrastructures).

The irrigation perimeter is organized into two irrigation districts: *Dx Volturno* and *Sx Volturno*. Both districts are divided into irrigation sub-districts, as shown in the Table 1.

Table 1. Sannio Alifano, districts of irrigation

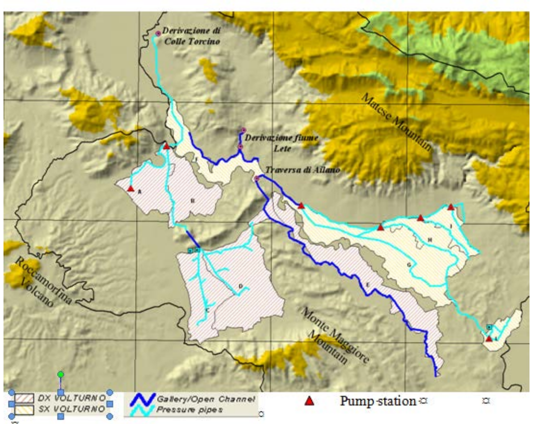
District	Sub-district	Principle Supply system		Distribution system	
		Pressure pipes	Open channel	Pressure pipes	Open channel
Dx Volturno	A - Piana di Presenzano	X		X	
Dx Volturno	B - Piana di Vairano	X		X	
Dx Volturno	C - Piana di Riardo-zona bassa	X		X	
Dx Volturno	D - Piana di Riardo-zona alta	X		X	
Dx Volturno	E - Piana di Baia Latina		X		X
Sx Volturno	F - Piana del Lete	X	X		X
Sx Volturno	G - Piana Alifana: zona bassa	X		X	X
Sx Volturno	H - Piana Alifana: zona media	X		X	X
Sx Volturno	I - Piana Alifana: zona alta	X		X	X
Sx Volturno	L - Piana di Gioia Sannitica	X		X	

Source: INEA, 2011

Main water resources are taken from the Volturno and Lete rivers Regarding irrigation infrastructures, the main water distribution systems consist of about 253 km of irrigation network of which about 179 Km is pressure pipe and 74 Km is open channel. This allows water to be supplied to the entire irrigation perimeters, also using several pump stations along the network.

The different types of irrigated surface (6,777 Ha under pressure and 3,958 ha by gravity) allow different irrigation types at farm level, with different levels of efficiency. The most efficient system is represented by sprinkler irrigation (in recent times, drip irrigation (more efficient) is being applied for tree crops), and the lowest by the border and furrows system. The range of efficiency is, especially for sprinkler irrigation and border and furrows system, linked with the different local conditions and soil properties.

Figure 2 - Irrigation network of Sannio Alifano, reclamation consortium



Source: INEA, 2011

METHODOLOGY AND PREPARATORY CAMPAIGN

The methodology is based on the calculation of the Crop Water Requirements (CWR) using the Penman-Monteith equation (Allen *et al*., 1998) with appropriate values of canopy variables such as crop height (h), surface albedo (r) and Leaf

Area Index (LAI) (D'Urso & Menenti, 1995, D'Urso, 2001). Spatial and temporal variations of the canopy variables are derived from space Earth observation (EO) optical data. The approach was tested and validated the first time during the DEMETER project in 2005 (D'Urso & Calera). For the SIRIUS project, the information on CWR was implemented into the decision support system (DSS) SPIDER (System of Participatory Information, Decision-Support and Expert Knowledge for irrigation and River-basin water management) for visualization and calculation of irrigation advices.

The preparatory campaign was carried out in the *Sannio-Alifano* pilot area. In the irrigation season 2011, a total number of 21 agricultural farms with 136 plots participated at the "Dry Campaign" to test and fine-tune the SPIDER DSS. This activity was carried out in preparation for the operation campaign that will take place in 2012. The total area under investigation consisted of 600 Ha mainly cultivated with corn, tomatoes, alfalfa, fruit trees and vineyards. During this campaign, the total number of generated irrigation advices was about 1260 covering a period 12 weeks (June-September). In average, the farmer received 9 irrigation advices per plot during the irrigation season.

Operative weeks	Acquired 13/06/11	20/06/11	27/06/11	04/07/11	11/07/11	18/07/11	25/07/11	03/08/11	12/08/11	19/08/11	23/08/11	07/09/11
(05/09/2011 - 11/09/2011)												7/9/11
(22/08/2011 - 28/08/2011)											22/8/11	
(15/08/2011 - 21/08/2011)										19/8/11		
(09/08/2011 - 14/08/2011)									12/8/11			**R**:received
(01/08/2011 - 08/08/2011)								3/8/11				**D**:delivered
(18/07/2011 - 24/07/2011)							18/7/11					
(11/07/2011 - 17/07/2011)						11/7/11						
(04/07/2011 - 10/07/2011)					8/7/11							
(27/06/2011 - 03/07/2011)				29/7/11								
(20/06/2011 - 26/06/2011)			22/6/11									
(13/06/2011 - 19/06/2011)		16/6/11										
		R D	R D	R D	R D	R D	R D	R D	R D	R D	R D	R D

Table 2. Summary of the irrigation advices for the year 2011.

The irrigation advices were generated using EO data from the DMC (DEIMOS-1) satellite with a spatial resolution of 22 m. A summary of the weekly irrigation advices and data used for their generation is reported in Table 2. A set of field measurements were carried out contemporaneously to satellite acquisitions to characterized the LAI. An example is reported in Figure 3 and Figure 4 for Maize and Alfalfa respectively.

Figure 3 Temporal evolution of the LAI as observed from satellite sensor data (DMC DEIMOS-1) and estimated from ground measurements for a maize plot.

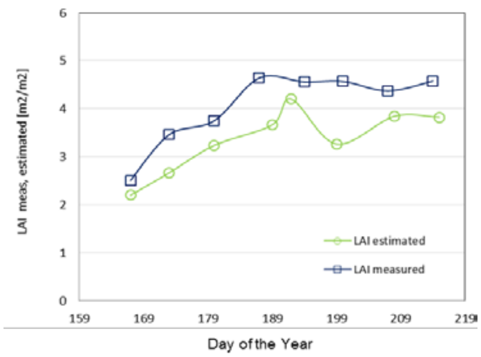
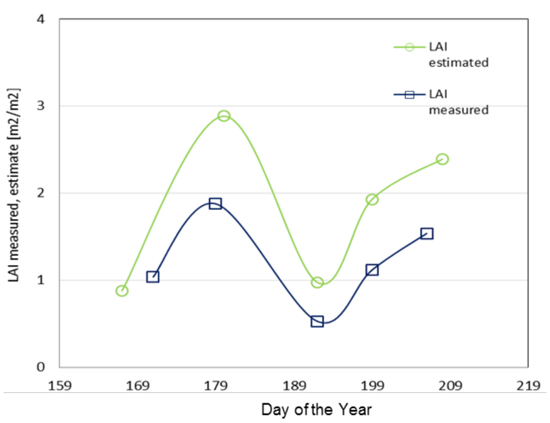


Figure 4 Temporal evolution of the LAI as observed from satellite sensor data (DMC DEIMOS-1) and estimated from ground measurements for a maize plot.



CONCLUSION

The preparatory campaign provided the framework to fine-tune methodologies and processing procedures for providing irrigation advisory services in real-time during the operational campaign in 2012. A feasibility study for the acquisition of satellite data with adequate revisit time and suitable spatial and spectral resolution was performed. A total of 12 DMC (DEIMOS-1) multispectral images were acquired with an interval of about 10 days. The spatial resolution of 22 was suitable to differentiate the heterogeneous agricultural structure of the area. Additionally, ground measurements of LAI were performed to further consolidate models used to estimate canopy variables and CWR.

Some of the expected outcomes will derive from the activity of SIRIUS satellite image analysis. These include the production of thematic maps of the area (i) agricultural and environmental maps of irrigated areas during the seasonal development of the crop (ii) maps of indicators of performance (iii) maps irrigation needs, (iv) maps of pesticides and fertilizers applied, (v) maps statistics and analysis economic statistics maps.

So far GMES has only aimed to develop large scale Core Services that did not attempt to address challenges such as water and irrigation management at the local and regional levels. SIRIUS defines the necessary components for a sustainable GMES water resources management service architecture by continuing to build on the SPIDER successful experience from the past FP5 and FP6 projects. Such strategy is very important for the stakeholders and potential end users.

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LITERATURE

Bazzani,G.M., Di Pasquale, S., Gallerani, V., Morganti, S., Raggi, M., Viaggi, D..The sustainability of irrigated agricultural systems under the Water Framework Directive: first results. Environmental Modelling & Software 20 (2003), pp 165 - 175.

G.D'Urso, A.Calera Belmonte, "Operative Approaches To Determine Crop Water Requirements From Earth Observation Data: Methodologies And Applications," AIP conference proceedings 852: Earth Observation for Vegetation and Water Management, pp. 14-25, Naples, Italy, 10-11 Nov 2005.

Randall, A., 1981. Property entitlements and pricing policies for a maturing water economy. The Australian Journal of Agricultura Economics 25 (3), pp 195 - 220.

IPCC, (2007) Climate Change 2007: The Physical Science Basis – Summary for Policymakers. Contribution of WGI to the 4th Assessment Report of the IPCC. Geneva

Goubanova, K., Li, L. (2006) Extremes in temperature and precipitation around the Mediterranean in an ensemble of future climate scenario simulations. Global and Planetary Change, doi:10.1016/j.globaplacha.2006.11.012.

Rodriguez Diaz, J.A., Weatherhead, E.K., Knox, J.W., Camacho, E. (2007) Climate change impacts on irrigation water requirements in the Guadalquivir river basin in Spain. Regional Environmental Change 7, 149-159.(UNESCO) 2006.2nd UN World Water Development Report, 2006.

EEAA, European Environment Agency No 2/2009 water resources across Europe – confronting water scarcity and drought. Copenhagen. ISBN 978-92-9167-989-8

Allen, R.G., L.S. Pereira, D. Raes, and Smith, M. 1998, Crop evapotranspiration: Guidelines for computing crop water requirements. Irr. & Drain. Paper 56. UN-FAO, Rome, Italy.

ISTAT (2007), la situazione nel Paese nel 2007. Rapporto Annuale 2007. Italy,Rome.