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STRATEGIE INTEGRATE PER AFFRONTARE LE SFIDE CLIMATICHE E AGRONOMICHE NELLA GESTIONE DEI SISTEMI AGROALIMENTARI

INTEGRATED STRATEGIES FOR AGRO-ECOSYSTEM MANAGEMENT TO ADDRESS CLIMATE CHANGE CHALLENGES

MILANO
12 - 14 SETTEMBRE 2017

A CURA DI
FRANCESCA VENTURA
GIOVANNA SEDDAIU
GABRIELE COLA

DIPARTIMENTO DI SCIENZE AGRARIE - UNIVERSITÀ DI BOLOGNA

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Strategie integrate per affrontare le sfide climatiche e agronomiche nella gestione dei sistemi agroalimentari

Integrated strategies for agro-ecosystem management to address climate change challenges

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A SURVEY ON REGIONAL AGROMETEOROLOGICAL NETWORKS IN ITALY
INDAGINE SULLE RETI AGROMETEOROLOGICHE REGIONALI IN ITALIA

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Abstract

The agrometeorology plays a primary role in building DSS – decision support systems - to face the challenges derived from climate changes, as stressed also by the recent *Common Agricultural Policy* (CAP 2014-2020). The AGROMETEORE project aims at improving and widening the resources on agrometeorology, available at NUTS2 level (administrative regions, in Italy), through the institution of a National Task-Force (NTF), focused on stimulating the resource sharing among the different NUTS2 Agrometeorogical Services (ASs) and their interoperability. As a first step in this process, a questionnaire on the main features of station networks and on data flows, processing and divulgation has been administered to each regional representative of the NTF. The survey has highlighted a great heterogeneity among the different services: some of these are fully operative, while others are in a reorganization phase. An important information derived from the survey is the encouraging value of the overall station density, referred to the Utilized Agricultural Area (UAA), which is comparable with the main European agricultural districts. The paper provides a preliminary overview of the state of the ASs in Italy. Some further results will be derived from the next activities of the NTF.

Keywords: agrometeorology, agrometeorological services, agrometeorological bulletins, meteorological network, weather stations.

Parole chiave: agrometeorologia, servizi agrometeorologici, bollettini agrometeorologici, rete meteorologica, stazioni meteorologiche.

Introduction

The agrometeorology plays a primary role in building DSS – decision support systems - to face the challenges derived from climate changes. The recent *Common Agricultural Policy* (CAP 2014-2020) has stressed the need to use agrometeorological applications in the field of Integrated Production and Organic Farming. Moreover, in order to implement the Directive 2009/128/CE on sustainable use of pesticides, each Country has to adopt a National Action Plan. The Italian plan (*Piano d'Azione Nazionale per l'uso sostenibile dei prodotti fitosanitari*) binds also the administrative regions to provide adequate agrometeorological services as support for farmers. Within the framework of the National Rural Network, the AGROMETEORE project has been designed with the aims at improving and widening the resources on agrometeorology, available at national and regional level, also through the institution of a National Task-Force (NTF) with representatives of all Italian administrative regions (and autonomous provinces, henceforth named "regions"). The NTF activities focus on stimulating the resource sharing among the different regional services and their interoperability.

As a first step in this process, a questionnaire has been administered to each regional representative of the NTF. The questions were related to the main features of station networks and to data flows, processing and divulgation at regional level. A similar investigation was already carried out in 2000 (Micale, 2000), when most Agrometeorogical Services (ASs) had been already developed (the first ones started in 1985) or were being developed. A more recent survey, mainly focused on the status of agrometeorological data networks, was accomplished by Marletto (2016). The results were based on regional reports on the sustainable use of pesticides (Dir. 2009/128/EC) and on information available on regional websites.

In this paper an updated overview of regional agrometeorological networks and of the status of provided services is presented and discussed.

Materials and Methods

The survey has been based on a questionnaire, administered to each regional representative of the NTF. The questionnaire has been implemented as a web form using Google Forms; it mainly consisted of closed-ended questions in order to ensure standardized responses to facilitate the filling out. In addition, a guideline document has been provided to the respondents.

The questionnaire has been structured in the following sections: (a) respondent's general data; (b) detailed information on agrometeorological network; (c) synergies among different meteo networks; (d) measured variables; (f) data flow; (g) climatology; (h) dissemination and communication; (i) critical issues.

The forms were administered in July 2016 and they were completely filled-out by most regions within October 2016. Only Umbria and Bolzano representatives returned a partially completed form. Data collected have been processed also by using ArcGIS® software by Esri to provide some statistics and maps useful to define a framework of the ASs in Italy.

Data on geographical distribution of agrometeorological sensors have been derived by computing regional station densities

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in relation to the Utilized Agricultural Area (UAA) estimates drawn by the Italian National Institute of Statistics (Istat, 2010).
Other data sources used in order to compare the Italian results with the main European Countries, are the WAMIS report of the World Meteorological Organization (WMO, 2009) and EUROSTAT statistics on European UAA (European Commission Eurostat, 2010)

Results and Discussion

The results obtained are quite representative of the current state of the ASs in Italy, as the non-response rate is very low (only 2 of 21 respondents sent partially completed forms).
The first information collected relates to the organization of the ASs in the different administrative regions. As showed in figure 1(a), the local office engaged in this field depends on different institutions. The reference office is a service (agrometeorological or phytosanitary) of the regional Department of Agriculture in 7 regions, it is a local Agency for the Agricultural Development in 6 cases, while in 4 regions the office is a Regional Agency for the Protection of the Environment. Finally, 4 regions engage an external company.

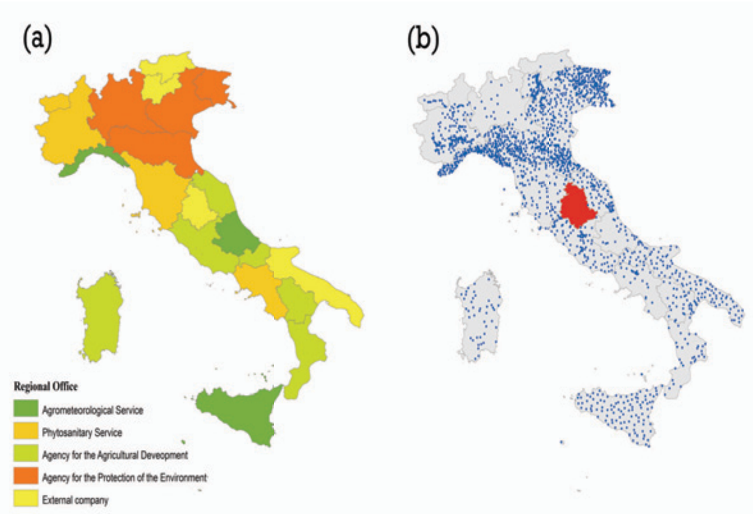

*Fig. 1: Reference institutions for the agrometeorology in the Italian administrative regions **(a)**; geographical distribution of the automatic weather stations used by the ASs; red color indicates no data **(b)**.*
*Fig. 1: Istituzioni responsabili dei servizi agrometeorologici nelle diverse regioni italiane **(a)**; distribuzione geografica delle stazioni meteorologiche automatiche utilizzate dagli ASs; il rosso indica dato non pervenuto **(b)**.*

It is remarkable that all Italian NUTS2 have currently their own agrometeorological services. A study carried out in 2000 reported that a half of services had an experience of more than 10 years, while some of these were going to start their activity (Micale, 2000). Therefore now the services have an experience which ranges from more than 30 to at least 15 years.
The core of the survey is the recognition of the main features of the agrometeorological networks at NUTS2 level[1]. The figure 1(b) illustrates the overall distribution of the 1832 automatic weather stations used by the ASs for agrometeorological purposes. The figure highlights an almost heterogeneous density among the different regions. It should be underlined that there is a case of non-response, related to the Region Umbria (red colour), perhaps due to the recent earthquake issues. A special attention should be paid to the high network density recorded in some northern regions (Liguria, Emilia Romagna, Friuli Venezia Giulia), where the agrometeorological networks are strictly integrated with other meteorological networks.
In addition to the automated stations, the survey has revealed that some mechanic stations (approximately 70) are still operative, mainly located in Emilia Romagna (these latter ones are not reported in the map in figure 1).
A more detailed information is derived by the table 1(a), which reports the station density, referred to the UAA, at NUTS2 level. Such density is quite high for almost all NUTS2 agrometeorological networks, with peaks of 37 and 10 stations per 10,000 ha of UAA in two Northern networks (Liguria and Friuli Venezia Giulia, respectively), also due to a different organization of the ASs. At a national scale, the average density of the agrometeorological network assumes a value of 1.4 per 10,000 ha of UAA.
The noticeable availability of agrometeorological stations in Italy have already been highlighted in relation to the other European Countries. The table 1(b) shows some results on the number of stations in the network of agrometeorological observations, drawn from a global survey on the National Meteorological and Hydrological Services (NMHSs) carried out in 2009 (WMO, 2009). With reference to the European context, aside the number of stations, the table reports the relative density per 10,000 ha of UAA computed using the Eurostat UAA of 2010 (European Commission Eurostat, 2010). In order to compute such density, 2010 has been chosen as reference year, as UAA data of 2009 were not available for Italy. The Italian value of 0.23 is remarkably higher than densities reported for most other southern and eastern countries and is quite in line with the Germany one.

[1] *Nomenclature des Unités Territoriales Statistiques -second level* corresponding to the Italian administrative regions

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More detailed information has been collected about automated stations. As regards WMO standard compliance, it has been assured for most stations (at least 50%) in 14 regions, while less than 25% of stations meet these standards in 5 regions, mainly located in Northern and Central Italy. With reference to the location, most stations (at least 50%) are located in agricultural areas in 18 regions and their altitude is lower than 400 m asl in 16 regions. Higher altitudes are generally few represented; they characterize more than 25% of stations only in Veneto Region. A further attribute is related to the station working: overall, more than 75% of the stations are active in almost all regions and their maintenance is carried out by an external company in 12 regions. The maintenance periodicity ranges from sub-six-monthly to annual in all regions but 4, which assure only extraordinary maintenance. Moreover there is a case (Umbria Region) in which no maintenance is carried out.

Tab. 1: Density of agrometeorological stations in relation to Agricultural Area in Use in the administrative regions. Data sources: questionnaire responses for the number of stations of agrometeorological networks and Istat statistics for UAA data (Istat, 2010) ***(a)****. Density of agrometeorological stations in relation to Agricultural Area in Use in most European Countries. Data sources: WAMIS report of 2009 for the number of stations in the network of Agro-meteorological observations (WMO, 2009) and Eurostat statistics for UAA data of 2010. (2009 UAA is missing for Italy)* ***(b)****.*
Tab. 1: Densità di stazioni agrometeorologiche rapportate alla SAU delle regioni (o delle province autonome). Fonti: il numero di stazioni è tratto dalle risposte del questionario, mentre per la SAU sono state utilizzate le statistiche ufficiali dell'Istat (2010) ***(a)****. Densità di stazioni agrometeorologiche rapportate alla SAU nazionale in vari paesi europei. Fonti: il numero di stazioni è stato tratto dal rapporto WAMIS del 2009 (WMO, 2009), mentre la SAU si riferisce al dato Eurostat del 2010 (la stima Eurostat del 2009 per l'Italia non è disponibile)* ***(b)****.*

(a)

Region level (NUTS 2)	Number of stations	UAA 2010 (ha)	Station density (no./10,000 ha)
Piedmont	140	1,008,173	1.4
Aosta Valley	12	58,388	2.1
Lombardy	25	977,383	0.3
South Tyrol	2	237,285	0.1
Trentino	85	143,190	5.9
Veneto	171	800,741	2.1
Friuli Venezia Giulia (*)	219	219,047	10.0
Liguria (*)	168	44,869	37.4
Emilia Romagna (*)	300	1,078,960	2.8
Tuscany	97	757,431	1.3
Umbria	65	326,239	2.0
Marche	70	470,510	1.5
Lazio	92	637,406	1.4
Abruzzo	24	454,362	0.5
Molise	26	197,472	1.3
Campania	28	546,948	0.5
Apulia	94	1,287,107	0.7
Basilicata	40	519,137	0.8
Calabria	36	549,198	0.7
Sicily	96	1,387,559	0.7
Sardinia	42	1,154,641	0.4
Italy	**1832**	**12,856,048**	**1.4**

(*) these regional values include also non-agrometeorological stations

(b)

	Number of stations	UAA 2010 (ha)	Station density (no./10,000 ha)
Bulgaria	29	5,051,860	0.06
Denmark	70	2,676,200	0.26
Germany	500	16,704,040	0.30
Ireland	26	4,568,930	0.06
Greece	15	4,839,390	0.03
Spain	25	23,719,230	0.01
Italy	**300**	**12,885,190**	**0.23**
Lithuania	43	2,772,300	0.16
Luxembourg	25	131,220	1.91
Portugal	11	3,653,800	0.03
Romania	55	14,156,480	0.04
Slovenia	53	482,650	1.10
Slovakia	50	1,921,610	0.26
Bosnia and He	10	1,715,000	0.06

A particular attention has been paid to the sensor equipment of the stations, in order to know the actual suitability and potentiality of the networks for agrometeorological applications. Aside from the main sensors of temperature and precipitation, which are installed on almost all stations, the regional networks are equipped with several other sensors, in a very heterogeneous way. The maps in figure 2 highlight the availability of the main sensors required for agro-meteorological aims, represented in terms of density in relation to the regional UAA. This density varies greatly depending on the parameter measured; overall it is higher for relative humidity and wind speed, which are measured in all regional networks, while it results very heterogeneous for solar radiation, leaf wetness and soil temperature. The soil temperature sensor is not available in almost a third of regional networks.
The maps show a high density for all sensors in some mountainous regions (Liguria, Friuli Venezia Giulia, Calabria and Trento province) as well as in Veneto and Marche (aside from soil temperature). The sensor density is instead relatively high for leaf wetness and relative humidity but quite low for the other three sensors in Piedmont and Umbria.
The questionnaire also surveyed the data recording interval adopted for each parameter in the different networks. The results have again highlighted the great heterogeneity among regions, but it is possible to draw out some common points: for almost all regions hourly values are recorded: hourly averaged values for air temperature, relative humidity, wind speed, atmospheric pressure and soil temperature (when these parameters are measured) and hourly total values for precipitation, solar radiation, leaf wetness. Some ASs adopt many different intervals to collect data; among these, in Emilia Romagna each parameter is recorded in the database for all the interval data (real-time, hourly and daily average or total or extremes values).

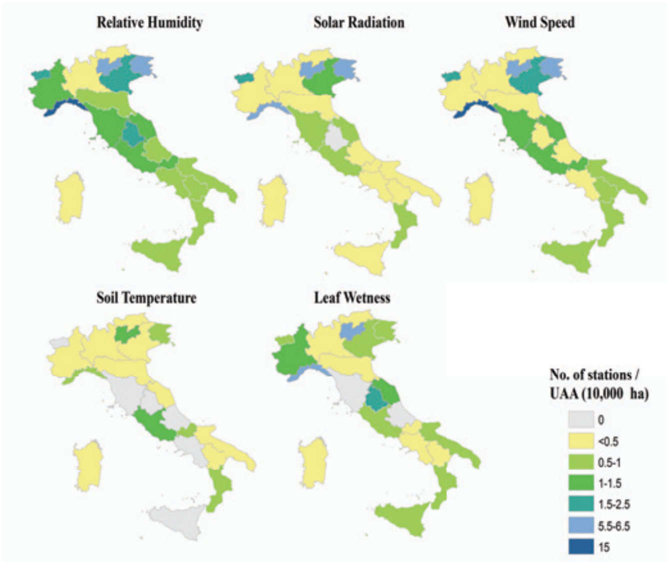

Fig. 2: Regional density of the main agrometeorological sensors per 10,000 ha of UAA.
Fig. 2: Densità regionale dei principali sensori agrometeorologici per 10.000 ha di SAU.

As regards the soil temperature, also the sensor depth has been investigated: with respect to a total of 15 regions where this parameter is measured, in most cases (12) there is at least a sensor at a maximum depth of 20 cm. Deeper sensors are located at a depth of 20-30 cm or higher than 30 cm in 5 and 6 cases, respectively.
A specific session of the questionnaire has been devoted to collect some preliminary information about data processing and storing for the implementation of the regional agrometeorological databases; this part will be further investigated within the NTF. Data quality control is performed by more than 2/3 of cases and 10 regions also compute validation indexes. Regarding to the missing data imputation, it is performed by almost a half of regions. Many regions (15) calculate agrometeorological indexes and several statistics, while evapotranspiration and leaf wetness are estimated by 9 and 3 regions, respectively.
As shown in the figure 3, data are spatialized by most regions, save 3 southern ones, and regular grids are applied only in 6 cases; however each regional dataset is independent from other ones and they are not homogeneous among them. Overall the spatial data resolution ranges from less than 5 km to more than 10 km.

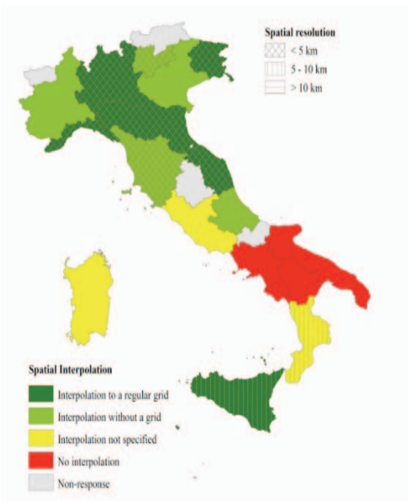

Fig. 3: Production of spatial agrometeorological data and related resolution at NUTS 2 level.
Fig. 3: Produzione di dati agrometeorologici spazializzati e relativa risoluzione a livello regionale.

Most regions use a modellistic approach to handle meteorological data in order to support farmers for pest and disease management; generally also phenological and crop models are applied. Moreover in 1/3 of cases the database is used for water balance modeling.
More than a half of regions calculate their own climatologies, with very different reference periods. In many cases, shorter and more recent periods, generally referred to the last 10-15 years, suitable for agrometeorological applications, are preferred to the standard periods (1961-1990, 1971-2000, 1981-2010).
The survey also focused on communication and dissemination activities, which are carried out by almost all regions. As reported in the figure 4(a), aside 3 non-responses, regions are equally divided in real-time/not real-time data publication; moreover, in many cases also more or less long time series are available. As shown in figure 4(b), in most cases specific

bulletins are issued with different periodicity; only 5 regions (red colour) don't publish any bulletin.

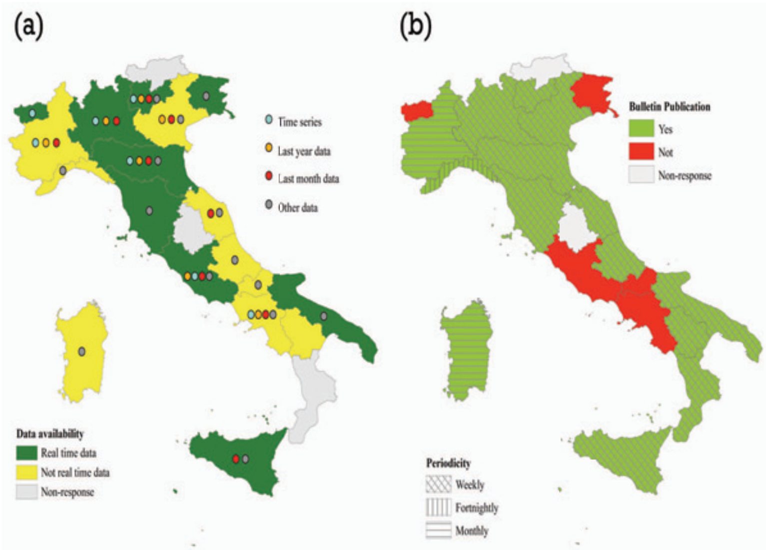

*Fig. 4: Real-time availability of agrometeorological open data and maximum length of accessible data series (**a**); agrometeorological bulletin publication and their periodicity (**b**).*
*Fig. 4: Disponibilità in tempo reale di open data agrometeorologici e lunghezza massima delle serie di dati (**a**); pubblicazione di bollettini agrometeorologici e loro periodicità (**b**).*

The last section of the questionnaire was devoted to gather information on the main critical issues encountered by each regional service in carrying out its activities. The most cited issues (approximately one half of cases) are referred to budget and personnel lack, network obsolescence and maintenance, data quality assurance, agrometeorological model design and implementation. Another weak point which has been underlined for several regions is related to the web communication. Overall, several critical aspects have been reported for most regions, aside 3 regions for whose any problem has been expressed. In some cases, it seems that these issues could threaten the efficiency of the services; even the ASs with a longer experience show a general need to be updated and improved.

Conclusions

The overall framework of agrometeorological services in Italy derived from the results of this preliminary survey is very heterogeneous, as already reported by Marletto (2016), with some strengths and some weaknesses. In particular, the main positive point lies in the quite high density (stations/UAA) of almost all NUTS2 agrometeorological networks. The survey has also pointed out many weaknesses, in particular related to the inadequate resources, such as the limited budget and the underpowered personnel, and to a general lack of interoperability among the different services.

In this regard, this study represents the first step of a process, to be realized in the framework of the AGROMETEORE project, for integrating and improving the agrometeorological resources currently available in Italy, in line with the proposal presented by Marletto (2016), with the aim of adequately meeting the CAP requirements.

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