Application of the radar data to forecast the epidemiology of grapevine downy mildew (*Plasmopara viticola*)

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INTRODUCTION

Leaf wetness is a very important agro-meteorological variable for prediction of plant diseases.

In particular, leaf wetness duration (LWD) represents a determining factor to predict plant diseases and to defend the crops (Huber et al., 1992).

Even if LWD measurements are usually part of environmental monitoring organized by most of national meteorological agencies, the lack of standardization of sensors and related measurements protocols (Sabatini et al., 2002) makes it difficult their practical utilization.

Moreover, the leaf wetness is a variable difficult to spatialize. This problem becomes even greater when leaf wetness is mainly due to rain and not to dew. In fact, as an example, convective rain is usually irregularly distributed over the plain.

This is the reason why a lot of local agencies, dealing with grapevine defence from different pathologies, have built a dense network of meteorological stations -- about 1,000 in Friuli Venezia-Giulia region.

An interesting alternative approach to the LWD monitoring is based on the utilization of remotely sensed precipitation measurements as an input for an agrometeorological model. Presently well calibrated ground radar can represent an eligible data source (Hoppmann et al., 1997), but is foreseen also the utilization of satellite-based measurements.

The study of the potential of such a strategy is investigated in the frame of COST 718 action "Meteorological Applications for Agriculture" (Dietrich et al., 2002).

The poster describes the results of the pre-operational version of a software to estimate LWD on Friuli Venezia-Giulia plane using meteorological stations data and radar data as inputs.

This software includes also a part to predict the development of a fungal pathogen, the Plasmopara viticola.

MATERIALS AND METHODS

The area is the Friuli Venezia-Giulia plain, where a network of meteorological stations as well as the C-band polarimetric radar located in Fossalon di Grado (Gorizia-Italy) provided measurements for this study (Cicogna et al. 2002).

Hourly meteorological data from 14 meteorological stations located in the study area (figure 1) and radar rainfall measurements (Bechini et al., 2002) were acquired for the period May-September 2000 and used as input for the leaf wetness duration model.

The choice of spring-summer period corresponds to the germination and development of fungal disease.

Territorial database was organized in daily agrometeorological gridded values having a spatial resolution of 0.5 x 0.5 Kilometers.

Punctual meteorological data, after accurate check and validation, have been interpolated over the territory by means of reliable spatialization techniques (Wachernagel, 1995), while radar rainfall measurements are operationally provided in such a gridded format.

A previous work (Cicogna et al., 2002) demonstrated a high correlation degree between the ground measurements of leaf wetness due to rain and the radar rainfall measurements. It is reasonable to make a joint use of stations and radar products to feed the leaf wetness model.

The model chosen to estimate leaf wetness is SWEB (Magarey, 2003).

This model consists of four parts. The first one describes water distribution on leaves, the second one makes a water balance on canopy, the third one solves an energy balance to calculate leaf wetness duration and the fourth one takes into account the wind impact on the wetting (or drying) of leaves.

Due to the lack of longwave net radiation measurements, SWEB model has been lightly modified for Friuli plain area. Following Cellier (1993, J. of Applied Meteorology, may 1993, 871-883), Brutsaert (1975) formula under clear sky conditions has been employed.

Finally, the availability of SWEB estimated gridded leaf wetness data allowed us to activate an epidemiological model running for each grid point.

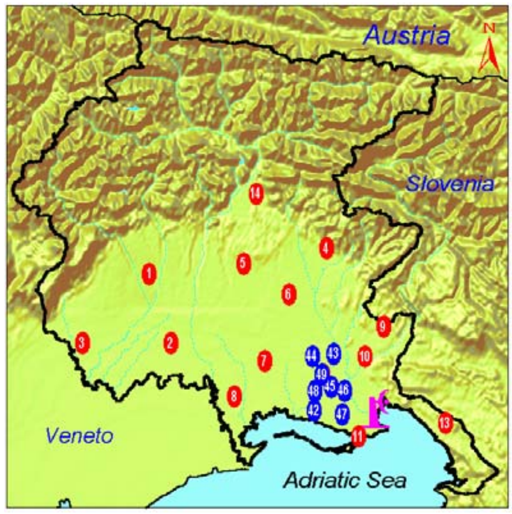

Figure 1. Position on the Friuli Venezia-Giulia plain of the meteorological radar ( ) and stations ( ) and of the 8 agrometeorological stations of DOC Aquileia. ( )

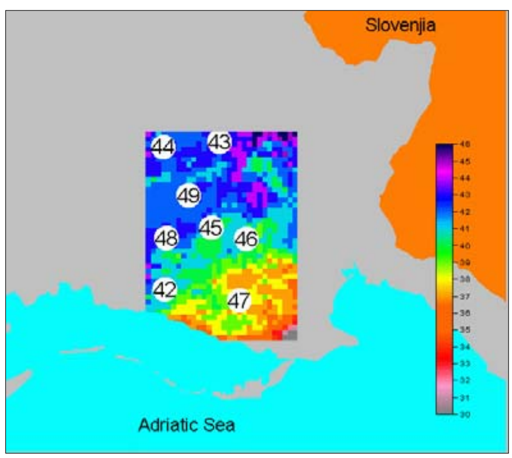

Figure 2. Example of the model output: total Plasmopara infections number on DOC Aquileia for day 30/09/2000

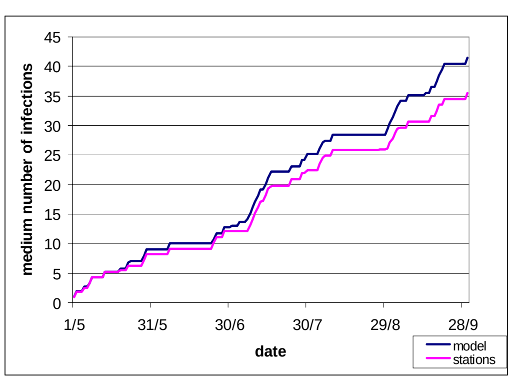

Figure 3. Average of the total number of Plasmopara infections on DOC Aquileia area during period 1/5/2000-30/8/2000. Comparison between estimates obtained by meteorological stations data and by model.

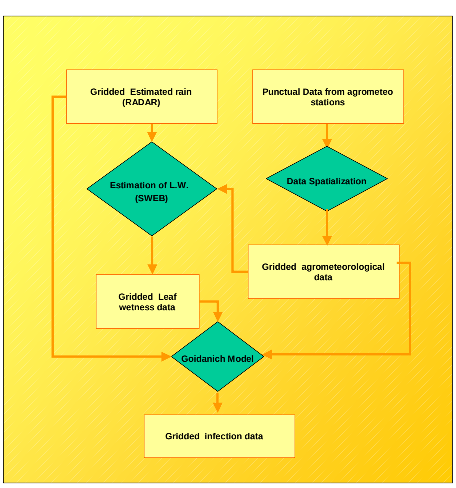

Figure 4. Flow chart of the algorithm used (left)

Since grapevine is a paramount crop for Friuli Venezia-Giulia, the model has been tested for Plasmopara viticola attacks on grape, due to the heavy impact of this pathogen on the grape-harvesting.

The development of Plasmopara viticola has been simulated by means of Goidanich model (Goidanich, 1964), since that model is already used extensively in some regional meteorological stations where is carried out an "aimed struggle" against plant pathogens.

The model, separately applied to each grid point, provided for every day of the study time: the number of Plasmopara viticola infections that are taking place, the prediction of the number of days needed to conclude the life cycle of every infection, and the number of total infections for the whole year.

To accurately verify the prediction system functionality, the study area was restricted by considering only a smaller part (DOC Aquileia) of the entire Friuli Venezia-Giulia plain (about 3000 km²). This area (about 200 km²) comprises 8 agrometeorological stations (figure 2) that are used to check the development of plant diseases.

Epidemiological data extracted in situ where the agrometeorological stations are placed are compared with those obtained using meteorological data measured by each station.

RESULTS

The contingency table (table 1) compares the number of total infections in the period 1/5/2000-30/9/2000 estimated with Goidanich model using data of 8 agrometeorological stations (observed data) and infection data extracted from the model gridded data (forecasts). The comparison shows a POD (probability of detection) equivalent to 95%, but also a false allarm rate (FAR) not negligible (21%). In table 1 are also presented the other skill scores obtained from the contingency table.

The analysis of the time series of the infections estimated by models and by stations data is displayed in figure 3. The periods in which Plasmopara viticola infections take place are almost the same and the model lightly overestimates the infection number.

Table 1. Comparison between total infection number during the period 1/5/2000-30/9/2000 estimated by Goidanich model using meteorological data from 8 DOC Aquileia stations (observed data) and data obtained by model gridded data (forecasts). H (Hit rate) 0.93, CSI (critical success index) 0.76, POD (probability of detection) 0.95, FAR (false alarm rate) 0.21, Bias 1.21.

		OBSERVED	
		YES	NOT
FORECAST	YES	203	54
	NOT	10	701

CONCLUSIONS

Using data gathered from few stations, radar data and simulation models for LWD (SWEB) in epidemiological models (for example Goidanich), we have obtained results comparable to those produced using data from a dense network of meteorological stations.

The relatively high number of false alarms (FAR) is not a real problem since it is much more important in Plasmopara viticola defence to ensure a high POD (probability of detection). As a matter of fact, it is better to overestimate infection, risking an additional fungicidal treatment against Palsmopara than losing grape wine production. Moreover, as shown in figure 3, Plasmopara infections are always present in groups more or less numerous. In practice, every group of infections is dealt by one or two treatments. So, an infection overestimated by 20% does not produce a similar increase of the fungicidal treatments.

The operational chain (shown in figure 4) is already a pre-operative system, capable to provide good information about the development of Plasmopara viticola on Friuli Venezia-Giulia plain, also outside the dense network of meteorological stations. Nevertheless the system can be further improved by using different leaf wetness models (Orlandini et al. 2002) and epidemiological models.

The outcome is that regions facing similar phytopathological problems but lacking in dense network of meteorological stations can employ the proposed approach gaining access to a reliable gridded source of precipitation data. The employment of satellite-based rainfall measurements is presently under investigation.

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