Interactive comment on "Real time drought forecasting system for irrigation management" by A. Ceppi et al.

Anonymous Referee #3

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General comments

The paper deals with an ensemble forecasting system and its usage to manage an irrigation system located in Northern Italy. Meteorological forecasts are the outputs of WRF-ARW runs provided by Epson Meteo Centre, up to 30 days ahead. They are used to force a hydrological model simulating water balance and soil moisture content dynamics, so that the benefits of planned irrigation scheduling can be evaluated and eventually changed in real time.

The topic of the paper is interesting and challenging, but I think a proper validation of the procedure is still missing. Only one growing season (2012) was considered to evaluate the reliability and the benefits of the forecasting chain, but the reliability assessment would definitely need more than a year of experiment and the benefits should be more clearly investigated by comparing two situations, one supported by the forecasting system and one without this system. Results are not well documented and not clearly explained.

Meteorological forecasts were available only during one growing season (2012), when we were able to test the reliability of our forecasting chain. However, we accept your idea to calculate the benefits of the PREGI system comparing two situations: one supported by the forecasting system and one without it, as we answered to referee 1.
As answered to other referee we are going to re-write the Section 4 "Results and Discussion", moving the statistical indexes in Section 3 and the "The PREGI platform" as supplementary data.

The potentials of the forecasting system for other case studies is not discussed, nor are its limits.

As written to reviewer 1, this system provides the monitoring and forecasting of soil moisture in a specific case study, but the replicability of this tool goes beyond this geographical and vegetated area. It is thought to be a web instrument where each landowner can know in advance future soil moisture conditions of his/her field and if he/she has to irrigate or not.

If we consider total costs of irrigation processes (water amount, its pumping system form the ditch, fuel for the tractor and labor cost), we understand the main advantage one can obtain form this forecasting system. As we wrote in the text "*A policy of saving the irrigation turn would be helpful if districts were subsequently affected by significant rainfall, but extremely dangerous if no precipitation will occur in the following weeks*".

Further, the contribution added by ensemble forecasts gives probabilistic information to be under or over certain stress/surplus thresholds with different forecast scenarios.

If we would like to replicate this system in other areas, one limit is to obtain real time data (weather and soil moisture information), amounts and scheduled days of irrigations, since they are not easy to obtain working in real time.

Rather than 'long-range' predictions I would talk about 'medium-range predictions', as usually one month-ahead forecasts are denoted.
We accept your suggestion.

English usage and style need to be revised, as well as the structure of the paper.
In chapter 2 a clear explanation of data used in this work and for model validation purposes is missing. Part of it is included in chapter 3 but should be moved in my opinion to chapter 2.

We accept your suggestion and we are going to revise the English and to join together the Section 2 and 3.
About data used in this work for calibration and validation of our hydrological model, as we mentioned to referee 2, the FEST-WB model requires:

- Observed weather data (temperature and precipitation)
- Scheduled irrigation: methods of irrigation, amounts of distributed water
- Measures of soil texture, hydraulic conductivity (Ks) in situ
- Type of vegetation with dates of sowing and harvest
- DEM (Digital Elevation Model),
- Aquifer data: this is an important feature if the groundwater interacts with the surface
- Soil moisture measures in situ

Further, soil parameters, reported in Table 1, need to be calibrated.

Some specific comments

Page 2 – line 10-14 The time scale of precipitation amount is not clear in these sentences.
There is not a unique time scale, we considered different available historical climatological data of 30, 50 and 100 years: in all of them there is not a significant decrease in precipitation amounts except for the last 20 years, as mentioned in Salerno et al., 2007, where a reduction of total precipitation has been observed.

Page 3- line 12 – Each acronym should be explained the first time it is mentioned. Here is WRF-ARW.
Ok, we explain here the acronym WRF-ARW (Weather Research and Forecasting - Advanced Research WRF)

Page 3 – line 26 – 'Average annual rainfall' over which time period?
This information is taken from the reference: Ceriani, M., & M. Carelli - Carta delle Pecipitazioni medie, massime e minime annue del territorio alpino della regione Lombardia, registrate nel periodo 1891 – 1990. Servizio Geologico, Ufficio Rischi Geologici Regione Lombardia, 2000 [in Italian].
The period used as reference mean is 1891-1990 and it is valid for the Lombardy Region.

Page 4 – line 6-7 - meteorological fields are available every two days? or every 12 hours (twice a day)?
As answered to referee 2, the meteorological forecast output (temperature and precipitation) are provided every 2 days by the Epson Meteo Centre: it is the time needed to run the combined GEPS-REPS system. However, the REPS-WRF used in this study, as mentioned in Section 3.1, has a forecast horizon of 30 days, the spatial resolution is 18 km while the temporal resolution is 12 hours. The meteorological model output becomes an input for the FEST-WB hydrological model to run soil moisture forecasts.

Page 5 line 5-6 – 200 m spatial resolution and daily time scale, you should discuss the suitability of this space and time scale for the goal of your analysis
The Livraga maize field is about 8 ha wide, hence a 200 m x 200 m as spatial resolution for our FEST-WB hydrological model was enough also from a computational time point of view.
About time scale, the landowner schedules his activities on daily-weekly basis, so we are not interested to have hourly soil moisture forecasts for the next four weeks, but a forecast for each day of the forecast time horizon is fully suitable for this study.

Page 5 line 7-8 – I guess the model is base on an inverse distance weighting technique as far as precipitation is concerned, not air temperature
The model is based on an inverse distance weighting technique both for precipitation and temperatures.

Page 5 line 11- how many field tests were carried out? 740 km2 is quite a wide area.

Our experimental field test is only one: the Livraga maize field where we had the possibility to install three TDR, one eddy-covariance station with other meteorological and hydrological instruments. This field is part of the Muzza Consortium Basin (MBL) which has an area of 740 km^2

Page 5 line 23-33 this is a bit confusing: the hydrological model was applied to the whole territory of the Muzza Bassa Lodigiana or only to the 8ha Livraga experimental field?
As written above the model was applied only in the Livraga experimental field where measures were done.

Page 6 line 33 – deduction of eq. 2 is not clear.

We report what we have written to referee 2:

According to FAO (Allen et al., 1998) the TAW is defined as: (field capacity – wilting point), while the RAW is defined as (field capacity – stress threshold).
From measurements done in situ the soil texture of Livraga maize field is a silt loam, hence from the handbook of hydrology (Maidment, 1993), field capacity and wilting point are equal to 0.33 and 0.133 respectively.

Following the equation in Baroni et al. 2010, where RAW = p · TAW (eq.1), the equation 2 for a maize field where p is assumed as 0.5, becomes:

Field capacity – stress threshold = p · (filed capacity – wilting point), hence the stress threshold we are looking for, is:

stress threshold = field capacity - p · (filed capacity – wilting point)

stress threshold = 0.33 – 0.5 · (0.33 - 0.133) then stress threshold is equal to 0.2315

Results and discussion- Figures and numbers provided only refer to the Livraga site, while it would be interesting to see how the hydrological model performs on the whole simulated domain (Livraga experimental filed?)

The PREGI forecasting system was tested only in the Livraga maize field. It was not possible to test our model in other fields of the Muzza Consortium Basin since no real measurements were done to calibrate and validate the hydrological model.

References - Two papers by Ravazzani et al. (2011) are actually listed, they shoud be probably cited as 2011a and 2011b.
Ok, this suggestion has been accepted.

Wilks (2006) is not listed, nor is Joliffe (2003) which should probably be substituted in the text by Joliffe and Stephenson (2003).
As mentioned to other referees, this suggestion has been accepted.