Hydrol. Earth Syst. Sci. Discuss., 10, C8220–C8226, 2014
www.hydrol-earth-syst-sci-discuss.net/10/C8220/2014/

Hydrology and Earth System Sciences
Discussions
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Interactive comment on "Real time drought forecasting system for irrigation management" *by* A. Ceppi et al.

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Received and published: 21 March 2014

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

Anonymous Referee #1

Received and published: 6 February 2014

The manuscript "Real time drought forecasting system for irrigation management" by Ceppi et al. presents an application of existing meteorological and hydrological models, coupled here to guide irrigation applications. The proposed framework is calibrated and validated over a specific case study site, a corn field in Northern Italy, for which

three-year eddy covariance and soil moisture data are available.

My main concerns regard the impact of the paper. In its current form, the manuscript provides an application of existing coupled meteorological and hydrological models for real time drought forecasting in one location in Northern Italy, with two-year calibration and one year validation. The impact of the paper would be greatly enhances should the author choose i) to discuss the applicability of the tool beyond the specific case study; ii) to objectively present strengths and weaknesses of the proposed modeling framework when applied for irrigation management; and iii) to quantify the advantage of employing such a tool.

Nowadays coupling meteorological and hydrological models is a common practice in the scientific literature thanks to the advance technology of super-computer and models. Our task in this study was to put into practice this scientific know-how as tool for a better irrigation management and planning. Working on the PREGI Project, funded by the Lombardy Region between years 2010-2012, we discovered how irrigation practices in the Po Valley area are left to very ancient strategies bounded more with landowner experiences than scientific studies and engineering processes. Hence, the aim of our research was to create a web application to help farmers monitoring real-time soil moisture conditions and forecasts, improving their irrigation scheduling, minimizing irrigation costs and saving water. We had the possibility to test our goal in one corn field in the Muzza Basin Consortium in northern Italy; however we remark that this forecasting system is applicable in every cultivated field and vegetated area. To run the hydro-meteorological chain, the system requires necessary data to feed the hydrological model in real time, in particular: - Observed weather data (at least temperature and precipitation) which are used to produce model initial conditions - Scheduled irrigations: amounts of distributed water and methods of irrigation Then, auxiliary information like soil texture, hydraulic conductivity (Ks), type of vegetation (dates of sowing and harvest), DEM (Digital Elevation Model), use and texture of soil, aquifer information are necessary to run hydrological simulations. It is not mandatory to install an eddy-covariance station (which has an expansive price), because the main hydrological variable is the soil moisture, hence TDR probes are enough to monitor and forecast it.

The first two points are crucial in defining the applicability of the proposed framework in routine, ‘real world’ problems – which, as far as I understand, is the final goal of the project. This discussion should include also clearer information on data requirements for model running, as well as information of the ability to the model to provide reasonable results upon calibration with a more limited (but more common) data availability. This system provides the monitoring and forecasting of soil moisture in a specific case study, but according to what mention above 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. 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”. Hence, the main advantage one can obtain form this forecasting system is so important if we consider total costs of irrigation processes: e.g. water amount, its pumping system form the ditch, fuel for the tractor and labor cost. Further, the contribution added by ensemble forecasts gives probabilistic information to be under or over stress/surplus thresholds (we defined) with different forecast scenarios.

The last point, the quantification of benefits, aims at investigating whether such tool can really make a difference in water management. The first step in this direction is clarifying what role the model suggestions played in the investigated case: this point is currently not very clear, with an irrigation application the day before a major rainfall event, but also a hint to the farmer employing PREGI in his/her water management choices (also, if the forecast was used for water management, how could that be done before model calibration?)

This is a true statement which maybe we didn’t clarify in the paper. The PREGI platform

was operative only when meteorological forecasts were available in the year 2012, after two years (2010 and 2011) used as calibration set for our hydrological model. Hence, the occurred irrigation on 14 June 2010 just one day before a significant rainfall event was not possible to avoid, since the PREGI tool with meteorological forecasts was not ready yet. In fact, when the PREGI was complete for the 2012 vegetation season, it was used to postpone the scheduled irrigation on 29 July one week later (i.e. on 6 August) and to extend the vegetation season in Livraga maize field till the end of August when maize was finally harvested.

A more in-depth exploration of the advantages of such a toolbox – which I strongly suggest - would require run two season-long simulations, one assuming the farmer follows the PREGI platform suggestions for when to irrigate, the other assuming that the farmer follows the currently employed decision criteria (which could even be as simple as irrigation applications whenever possible). The comparison of total applied water between the two runs will make it possible to assess the benefits of such a system in terms of water savings, the difference in total transpiration (or occurrence of periods with low soil moisture) can be used as a (rough) proxy of yield. A similar analysis could be extended beyond the three-year timeframe, to fully assess the advantages of such a system under a variety of climatic conditions.

This is an important issue we accept to carry out only over the 2012 growing season where the WRF model forecasts were available. We are going to re-run the hydro-meteorological chain and to check how many irrigations were really necessary if the landowner follows the PREGI platform suggestions for when to irrigate.

Additional comments:

The model undergoes a calibration based on the data available at the case study site. Nevertheless, no mention is made of which parameters need calibration. This is an important information when considering the applicability of the model beyond the very specific (and data rich) case study (see above).

As mention above the required data set for the hydrological model tuning is:

- Observed weather data (temperature and precipitation) - Scheduled irrigations: methods of irrigation, amounts of distributed water - Measures of soil texture, saturated 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

On the contrary, to feed the hydrological model in real time, meteorological model forecasts (at least temperature and precipitation) and observed data are necessary to obtain initial conditions. Real evapotranspiration data have been obtained by the eddy-covariance measures, but this information was only used as a further check in the hydrological balance; it is not mandatory to have an expansive eddy-station to apply the PREGI system.

About the parameters used to calibrate the hydrological model, they are all reported in Table 1. However, if soil texture and measures of saturated hydraulic conductivity (Ks) in-situ are not available, you need to calibrate them. Finally, we calibrated the soil depth too.

The manuscript would greatly benefit from an in depth editing of English – in its present form, it is understandable, but does not read smoothly, with some grammar mistakes, not appropriate informal language, and an awkward choice of wording. Also, the text requires streamlining, avoiding repetitions of the same information (e.g., page 15814 "MBL covers an area of 740 km2. Within the 74000 ha. . .")

The English will be reviewed and repetitions will be corrected. Thanks for this suggestion.

The word 'turn' for the timeframe in which the farmer has water availability seems confusing to me – I suggest changing it to 'irrigation time allotment' or 'time slot' or more in general 'irrigation scheduling'.

This suggestion has been accepted. The word "turn" will be no more used.

The measures of model performance ought to be defined within section 2 (the scope of which should be broadened to 'Methods'), discussing what specific aspect(s) of model performance they allow assessing. In this way, the result section can be focused on just presenting the model performances.

The section 2 is referred to the area of study, hence if you refer to section 3 "Models" we are going to rename as "Models and Methods", including statistical indexes to value the model performance as you suggested us.

The description of data availability (now at the beginning of the result section) should be moved earlier, either by widening the scope of current section 2 or within a new subsection in section 3, which then should be broadened to 'Methods', as also suggested above).

This suggestion has been accepted and data availability will be moved into Section 3 with a better description of parameters and required data to run our simulations.

Fig. 2, 3, and 4 and Fig. 5 and 6 could be easily combined in two multi-panel figures, to facilitate the comparison across years and indices of model performance.

This is a good idea we accepted.

The presentation of the PRE.G.I. platform, including Fig. 8 and the description of the website, is unnecessary within the general economy of the paper and could be omitted/moved online as supplementary material.

Since the web platform had an important role in this Project, providing the possibility to check in real time soil moisture and precipitation forecasts in Livraga maize field for farmers, we decide to do not omit it, but to move it as a supplementary material at the end of the paper.

I suggest broadening the introduction and discussion with reference to other related works (also broadening the reference list – current references mostly refer to works focusing on the same region in Italy, which is relevant but not unique in the international arena).

In the text we mentioned international studies focused on the optimization of irrigation management as Cabelguenne et al., 1997, Gowing and Ejieji 2001, Jensen and Thysen 2003, Cai et al., 2007 and the DEWFORA Project which this latter gathers different studies about drought forecasting system in Africa countries at large scales. The only national reference is Ravazzani et al., 2011 about quarry lakes, tested as alternative water sources in the Po Valley area. However, we accept to find out more related works in different geographical areas.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/10/C8220/2014/hessd-10-C8220-2014-supplement.pdf

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 15811, 2013.