iColt: results from the summer operational seasonal predictions of irrigation water need in Emilia-Romagna

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WHY?

Water management is a crucial issue in Italy, especially in summer, when precipitation is at its climatological minimum and water is needed not only for civil purposes, but also for energy production and agriculture.

In Italy the authorities in charge of water management for agriculture are **land reclamation and irrigation consortia** and **regional departments**. These entities are the main **stakeholders** of the summer operational seasonal predictions of irrigation, focus of this work, yearly released since 2011 by the Regional Agency for Prevention, Environment and Energy of Emilia-Romagna (ARPAE).

WHERE?

The irrigation seasonal forecasts are produced on **Emilia-Romagna region,** located in Northern Italy, just South of the Po river and it is characterized by intensive agriculture connected with the food sector.

Usually the results are provided for the plain area of Emilia-Romagna and for each of the 8 irrigation consortia. In the current study, we present the results of the **reforecasts** obtained with the **current operational setup** for the Pilot Area of the land reclamation and irrigation consortium of Romagna (***Consorzio di bonifica della Romagna***), shown in Figure 1.

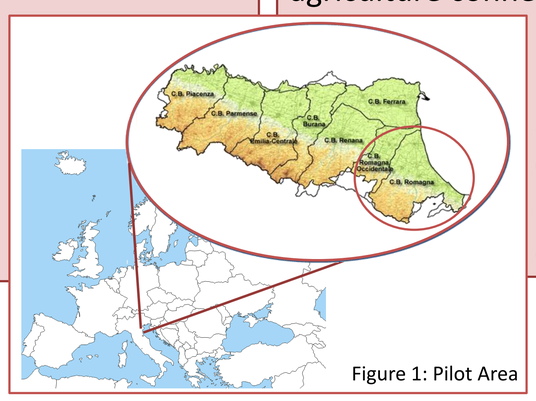


Figure 1: Pilot Area

WHAT? iColt prediction system

The system iCOLT (*irrigazione e Classificazione delle cOLture in atto tramite Telerilevamento* – irrigation and classification of current crops by remote sensing) integrates ensemble seasonal weather forecasts, satellite data, observed meteorological data and soil water balance so as to produce, by the end of May, ensemble irrigation predictions for the next season.

As shown in Figure 2 during the winter and spring months an **early crop map** is produced by means of three satellite images and field surveys.

During the last month of spring, calibrated probabilistic seasonal predictions are issued. At the beginning of summer the probabilistic predictions of summer irrigation are disseminated.

In the following autumn, the summer daily meteorological data are used as input of the soil water balance model so as to validate the predictions.

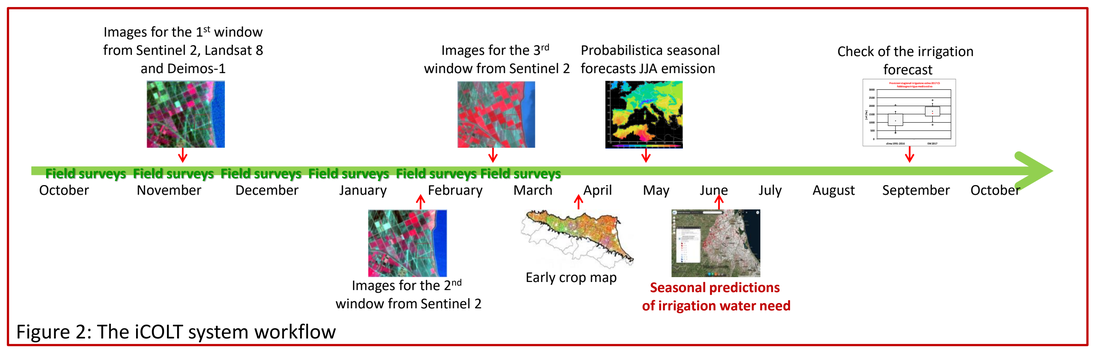


Figure 2: The iCOLT system workflow

HOW?

In Figure 3, the scheme of computational component of iColt is shown. Multi-Model seasonal predictions of a group of climate indices are obtained by applying a statistical scheme calibrating the **Copernicus multi-model seasonal predictions** to local climate. The climate indices predictions are used as input of a **weather generator** (WG).

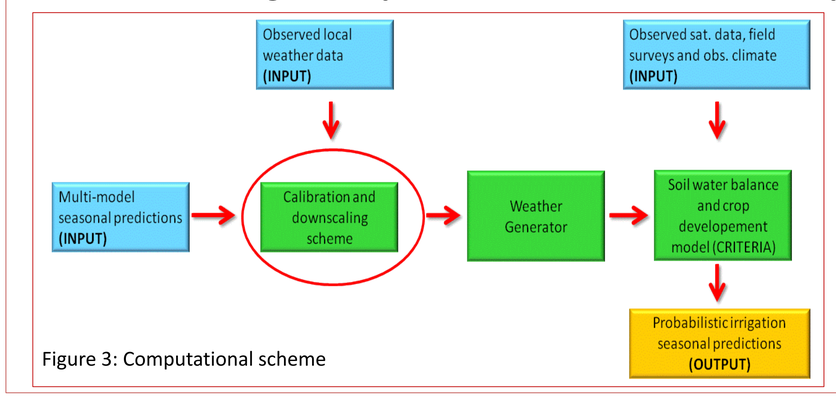


Figure 3: Computational scheme

The output of the WG is a time series of daily maximum air temperature, minimum air temperature and total precipitation, consistent with the values of the climate indices provided as input. The time series of daily data used to force the soil water balance model are obtained by adding three months of synthetic daily data, produced by the WG starting from the predicted climate indices, to the observed meteorological data of the 9 months preceding the forecast period. The synthetinc weather daily data, the observed data and the early crop map are used as input of the **soil water balance and crop development model** CRITERIA developed by Arpae (Marletto et al., 2007), so as to obtain the final probabilistic forecast of irrigation.

Reference: *Marletto, V., F. Ventura, G. Fontana & F. Tomei, 2007: Wheat growth simulation and yield prediction with seasonal forecasts and a numerical model. Agric. Forest Meteorol., 147, 71–79.*

Probabilistic climate predictions

Probabilistic seasonal predictions are characterised by limited skill scores over Europe. In the following it is done a comparison between the forecast ability of seasonal forecasts in the Pilot Area obtained using three different calibration methods:

- simple debiassing of the **Direct Model Output** (DMO);
- the **Multi Linear Regression** (MLR) scheme used to produce the irrigation predictions;
- **Quantile Mapping** scheme (QM).

Skill scores are evaluated over the period 2011-'18 using as reference the period 1991-2010. The skill indices presented are the Bias, the Brier Score and the Brier Skill Score for positive anomalies events.

Skill scores show that both the MLR and the QM predictions present some skill for precipitation which has no correspondence in DMO debiassed predictions. At the same time, prediction of T_{max} has a similar skill as climate predictions, for MLR and DMO while are not skillfull for QM.

Prec	Arpae MLR	QM	DMO debiassed
Bias	42.3 mm	35.8 mm	51.8 mm
BS	0.23	0.25	0.32
BSS	0.06	0.01	-0.30

Tmin	Arpae MLR	QM	DMO debiassed
Bias	-0.35°C	-0.25°C	-0.09°C
BS	0.27	0.25	0.24
BSS	-0.07	0.01	0.05

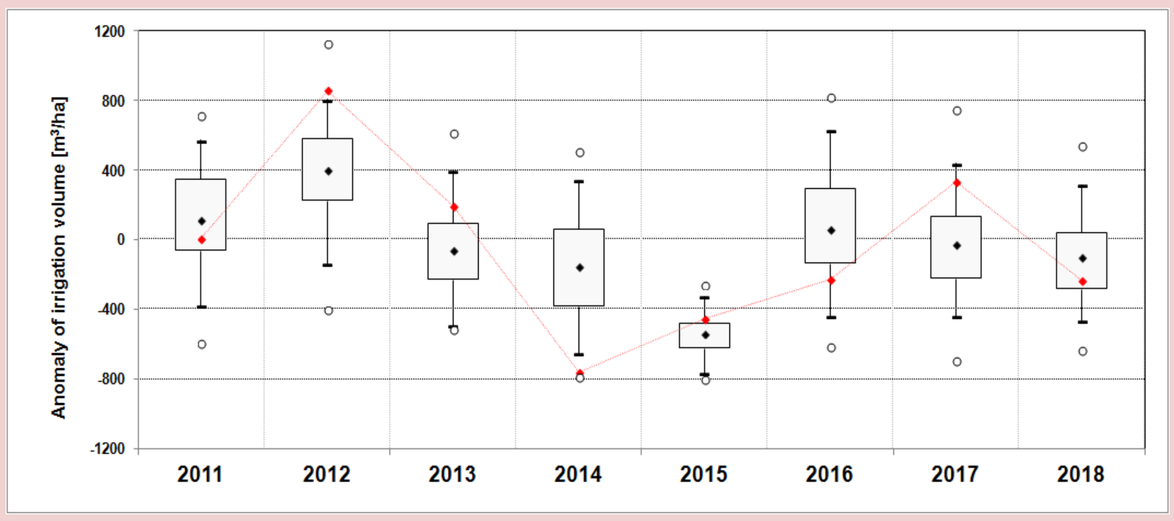
Tmax	Arpae MLR	QM	DMO debiassed
Bias	-0.49°C	-0.65°C	-0.46°C
BS	0.24	0.29	0.25
BSS	0.03	-0.16	0.02

T_{min} is well predicted by the DMO debiassed, but not by the MLR. For irrigation forecasts the crucial parameters are precipitation and T_{max}, so the MLR scheme seems to be better suited than the other methods in order to obtain irrigation forecasts.

Probabilistic irrigation predictions

Probabilistic irrigation predictions over the period 2011-2018 are produced over the Pilot area. Anomalies of summer irrigation need forecasts with respect to the period 1991-2010 are expressed as anomalies of irrigation volume (unit of measure: m^3/ha), shown in the plot below.

The graph presents the time series of box-plots of probabilistic forecast anomalies compared with the observed irrigation obtained by running the system using observed weather data (red dots).



In order to evaluate the results, the skill indices used are the **Brier Score** and the **Brier Skill Score** for positive anomalies events, that respectively are **0.16** and **0.36**. It means that the probabilistic seasonal irrigation predictions present good performances.

Conclusions

The present study shows that the iColt system is able to predict the sign of the irrigation water need anomaly with some skill. The skill of these predictions is thought to be mostly due to the dependence of soil water content on the meteorological conditions occurred over the preceding spring months and to the possibility to access maps of prevailing crop type distribution produced with satellite data. All the same, it is shown that the skill of the calibrated predictions of seasonal climate indices used as input of the system also positively contributes to the final results.

Acknowledgements

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