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Predicting Evapotranspiration in Crop Rotations With a Simple Model: AqYield

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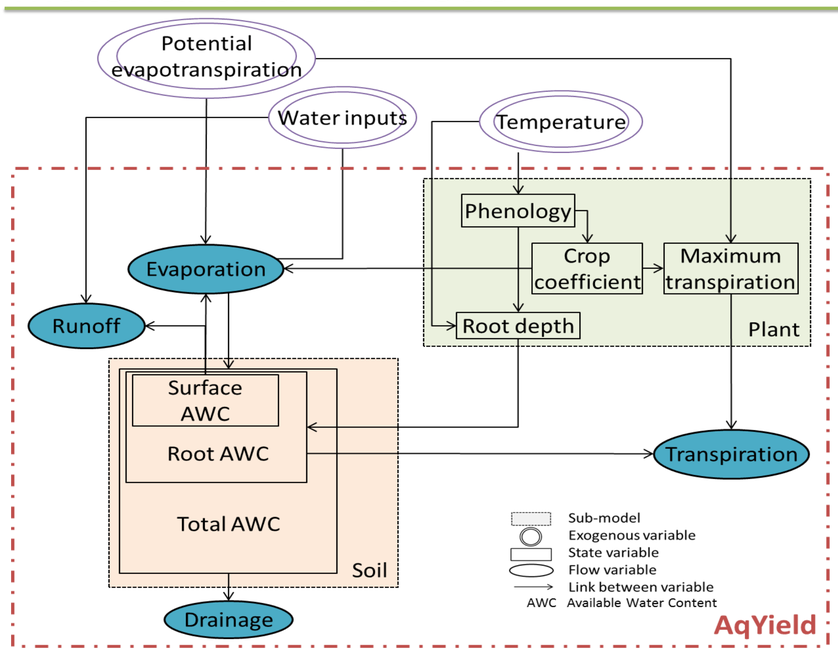
Context and objective

- Designing **cropping systems** that are well-adapted to water-limited conditions is one challenge of adapting agriculture to climate change.
- Quantifying the field **evapotranspiration** (ET) (plant transpiration + soil evaporation) according to their management is crucial because it has a direct impact on water availability in areas where water is scarce.
- The purpose of our study was to evaluate the ability of a simple model **AqYield** to predict water flux dynamic like ET at the field scale over crop rotations.

Material and Methods



- AqYield only requires few input data :
  - 4 soil properties (clay content, soil depth, maximal available soil content, pebble content)
  - 3 daily climate features (temperature, rainfall, potential evapotranspiration)
  - dates for crop management practices (sowing, harvest, soil tillage, irrigation).
- The model simulates water balance components (soil available water, ET and drainage) at a daily time step, phenological stages and yield. It has already been satisfactory evaluated for spring crops in southwestern France (Constantin et al. 2015).
- First, we calibrated and validated the model for wheat (main winter crop of France) using data from experimental French sites with contrasted climate and soil conditions with good efficiencies : 0.84 for calibration and 0.69 for validation (Tribouillois et al. 2018).
- Then, ET predictions from continuous run of AqYield were evaluated with observed ET measured at **two crop rotations** :
  - FR-Aur: wheat/ sunflower/ wheat/ rapeseed
  - FR-Lam: irrigated maize/ wheat.
- On each site **7 years** of continuous daily turbulent ET fluxes (Eddy Covariance) were measured.

Results

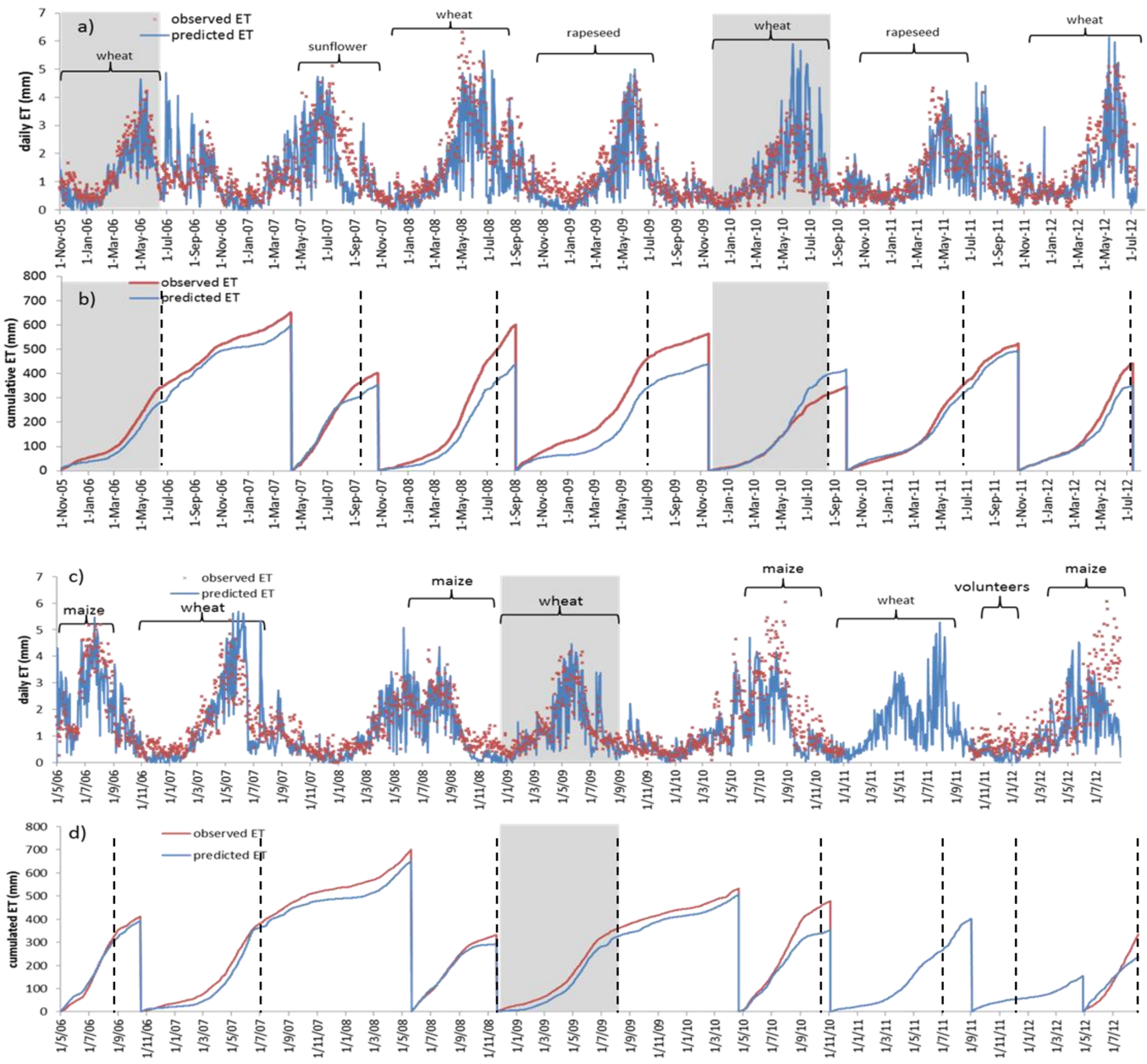


Figure 1. (a, c) Daily and (b,d) cumulative observed and predicted evapotranspiration (ET) during fallow and cropping periods for two crop rotations at the (a, b) FR-Aur and (c, d) FR-Lam sites from 2006-2012. Vertical dashed lines represent harvest dates. Gray areas represent wheat crops used for model calibration

- The simple equations and empirical processes in AqYield appears **relevant** enough to predict **daily and monthly ET flux dynamic** at the crop rotation scale with various crops on both sites.
- AqYield adequately reproduced **intra- and inter-annual variability** of observed ET fluxes, with accurate prediction of low and high ET for a variety of crops and contrasted climatic years (Figure 1).
- Globally ET was **slightly underpredicted**, especially at the end of growing seasons probably because physical limitation of evaporation due to aboveground biomass after flowering is not accurately simulated.
- At the crop-rotation scale, predicted monthly ET obtained also **good statistical criteria**: Ef = 0.72, rRMSE = 0.36 (corresponding to 16 mm) and MD = -7.0 mm (Figure 2).
- Daily ET predictions were as accurate than those predicted with the spatially distributed and more complex TNT2 model, which was partially evaluated using the same dataset (Ferrant et al. 2014).

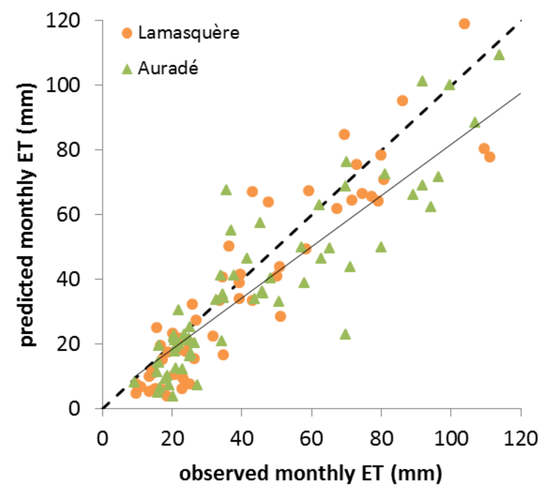


Figure 2. Observations vs. predictions of monthly evapotranspiration (ET) for two crop rotations at FR-Aur and FR-Lam sites for model validation.

Conclusion

- Whereas AqYield is simple and requires only a few input data, it allows accurate prediction of ET along cropping systems.
- It therefore could be useful as a module in more complex modeling approaches at the watershed level.
- For example, it can be used in the modeling platform MAELIA (http://maelia-platform.inra.fr/) for simulating agroecological practices in a variety of cropping system scenarios and their impacts on water balance under climate change.

References:
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