

Interactive comment on “Effects of multi-temporal high-resolution remote sensing products on simulated hydrometeorological variables in a cultivated area (southwestern France)” by Jordi Etchanchu et al.

Jordi Etchanchu et al.

jordi.etchanchu@cesbio.cnes.fr

Received and published: 3 April 2017

Anonymous Referee #2: “This paper focuses on the impact of vegetation dynamic on the simulation of evapotranspiration from a land surface model. It shows the benefits of using decametric resolution and high revisit frequency satellite imagery (FORMOSAT-2) to resolve the spatial and temporal dynamic of vegetation at the landscape scale and to drive the SURFEX/ISBA-A-gs land surface model. The authors compare - evapotranspiration (ET) simulated using the leaf area index (LAI) and a land cover map derived from FORMOSAT-2 satellite imagery, and - ET simulated using vegetation

C1

variables taken from the ECOCLIMAP-II database which is the land surface parameter database used for the spatial integration of the model and provides a monthly climatology for LAI at 1 km spatial resolution. The authors showed that the use of FORMOSAT-2 LAI improves the performances of simulated ET. The effects are more significant for summer crops than for winter crops. The issue addressed by this paper is of great interest for the land surface community. It shows the potential of new high spatial and temporal resolution satellite (SENTINEL-2) to drive land surface models using more accurate land surface characteristics. However, major revisions of the paper are needed before considering it for publication in HESS. There are a lot of confusing sentences, inaccurate definitions, some references are missing, some justifications are missing. The analysis of the results is not deep enough. A dedicated discussion section is missing. This alters the quality of the paper whilst there is enough scientific content for publication. I provide below some evidences and some suggestions for improvement. But this is not exhaustive. Substantial improvement of English and paper structure are also expected.”

Authors: Thank you for your comments. Several efforts have been done to clarify the paper. The references and justifications missing have been added. We have also decided to switch the evapotranspiration unit from a monthly averaged $J.m^{-2}.d^{-1}$ to a cumulated evapotranspiration over the month in $mm.month^{-1}$ in order to simplify the comprehension. Concerning the analysis of the results, as recommended, we have added a dedicated discussion part where we interpret each interesting aspects of the results. Especially, further work has been done to include a reflection about the uncertainties of both the measurements and the remote sensing products. Regarding the English improvement, we would like to mention that the paper was revised by American Journal Experts before the submission. The certificate can be downloaded from the Editor portal here: <https://secure.aje.com/download.php?action=certificate&key=BCD9-C850-DE8C-8F39-066A&t1490784542> . However, we did our best to further improve the English in the revised version.

C2

Anonymous Referee #2: "Specific comments - Abstract: it is too long, too many methodological details are given"

Authors: The abstract has been shortened. Methodological details have been suppressed while the main issues and outcomes of the study have been highlighted.

Anonymous Referee #2: "Introduction - page 2, line 4: please clarify the idea, provide examples of agricultural practices (irrigation, crop rotation, seeding date, . . .)"

Authors: This sentence was clarified as follows: "In an agricultural river basin, such as our study area, farmer's practices have an impact on vegetation dynamics. Farmers manage crop rotations, select variety, decide the seeding and harvest dates and organize irrigation supplements. In such basins, a more accurate description of crop dynamics and their effects on hydrometeorological fluxes is critical to improve the monitoring of water resources (Foley & al., 2005; Martin & al. 2016)."

Anonymous Referee #2: "- choose between Land surface model and SVAT to use in the rest of the text"

Authors: We decided to choose "Land Surface Model" for the entire article.

Anonymous Referee #2: "line 7: references are needed for SURFEX and VIC, - the meaning of SURFEX acronym needs to be given"

Authors: Because SURFEX is not exactly a scientific model but rather a modeling platform, we decided to use ISBA in this sentence. The ISBA acronym is defined and the references are added for both VIC and ISBA: "Land surface models (LSMs), such as the Variable Infiltration Capacity (VIC, Liang & al., 1994) or Interactions between the Surface Biosphere Atmosphere (ISBA, Noilhan & Planton, 1989) models . . ."

Anonymous Referee #2: "- the definition of LAI is not exact, it is defined as - "half the total developed area of green (i.e., photosynthetic active) leaves per unit ground horizontal surface area [Chen and Black, 1992]"

C3

Authors: Thank you for this comment. This definition and the associated reference have been added in the paper.

Anonymous Referee #2: "page2 , line 10: LAI is not an index. It is a variable that can be simulated by the model or used as a forcing variable to drive the model - page 2, line 10: please justify, a reference is needed here. LAI is the scaling factor to compute the stomatal conductance at the canopy scale. It is not necessary the most influential parameter on the simulated evapotranspiration"

Authors: As you wrote, the LAI is used to compute the stomatal conductance. It is not necessarily the most influential parameter on the simulated evapotranspiration. The meaning of this sentence was to say that the Leaf Area Index is the only variable representative of the vegetation dynamic to impact evapotranspiration calculation in most LSMs. As described in Noilhan & Planton (1989), the LAI is the only way the vegetation dynamic is taken into account in the evapotranspiration computation in the standard version of ISBA. The root-depth also impacts the maximum available water content to evapotranspiration but in our study, it is a fixed parameter given by ECOCLIMAP. The LAI is also the only vegetation variable to impact the evapotranspiration in VIC (Liang & al., 1994), in the Canadian Land Surface Scheme (CLASS, Verseghe & al., 1993) and the Joint UK Land Environment Simulator (JULES, Best & al., 2011). The other variables that influence the vegetative part of the evapotranspiration are either atmospheric or soil parameters. The advantage of focusing on the LAI is also that it is a biophysical variable which is observable from space. The sentence has thus been revised: "It is the main variable used to parameterize the effect of vegetation dynamics on evapotranspiration in most LSMs."

Anonymous Referee #2: "Page 2, Line 12: too many references, select one or two. This remark applies for the rest of the paper."

Authors: We kept Verseghe & al. (1933) and Maurer & al. (2002).

Anonymous Referee #2: "Page 2, Line 14: no needs to define a climatology - page 2,

C4

line 14: use the term climatology instead of climatological”

Authors: The term “climatological” has been replaced by “climatology” in the entire paper.

Anonymous Referee #2: “page 2, line 20: This holds for Europe but not for the US”

Authors: We totally agree with this remark. Indeed, MODIS could be sufficient in North America. This is probably the reason why Sentinel-2 is an EU program. Fritz & al. (2015) have done a global map of field size which could justify this sentence. The precision has been added: "However, for many cultivated areas and particularly in European countries (Fritz & al., 2015), field plot areas rarely exceed typical MODIS product pixel sizes (500 m, i.e., 25 hectares)."

Anonymous Referee #2: “Page 2, line 20-25: Redundancies, confusing sentences”

Authors: This part has been revised to suppress the redundancies and try to make the idea clearer to the reader: "As a result, MODIS pixels can contain mixed LAI signatures of different crop types with different phenologies. It thus degrades the actual temporal variability of the LAI on these fields. Consequently, it is not representative of the actual hydrometeorological behavior of the land cover. (Trezza & al., 2013 and Nagler & al., 2013)."

Anonymous Referee #2: “page 2 line 25-26: why ? References are needed”

Authors: Summer and winter crops have anti-correlated phenologies. So if their LAI signatures are mixed, the resulting cycle will be a nearly constant phenology throughout the year. The variability of the LAI will be attenuated or even suppressed. A sentence has been added to explain this: "Indeed, summer and winter crops have anti-correlated phenologies so mixing these two LAI signatures leads to attenuating, or even suppressing, the LAI variability throughout the year." However, there are no references in our knowledge that show this phenomenon.

Anonymous Referee #2: “page 2, line 27-30: redundancies with above”

C5

Authors: These sentences have been reformulated to suppress the redundancies: "A potential solution to access realistic vegetation dynamic could be the use of high resolution remote sensing products. The recently launched Sentinel-2 mission will generate multispectral imagery of land areas at a decametric resolution (10 m to 60 m depending on the band) over a 5-day revisit period. Previous studies have already shown that higher resolution data can improve descriptions of vegetation and modelled water processes in agricultural landscapes for which mid-resolution imagery is unsuitable (Ferrant & al., 2014; Ferrant & al., 2016)" We found it important to show that some studies have already been carried out to evaluate the impact of the high resolution remote sensing products.

Anonymous Referee #2: “page 2, line 31-32: ISBA should be defined”

Authors: The ISBA acronym is defined and referenced (Noilhan & Planton, 1989).

Anonymous Referee #2: “page 3, line5: ECOCLIMAP-II LAI are derived: from the analysis of MODIS LAI and not SPOT/VEGETATION”

Authors: You are perfectly right, it has been corrected: "It is a climatology derived from MODIS satellite observations collected between 1999 and 2005."

Anonymous Referee #2: “page 3, line 7-8: this is not clear. Provide thorough explanation on how LAI is computed in ECOCLIMAP-II”

Authors: The ECOCLIMAP-II is produced by the mean of an unmixing algorithm applied to MODIS LAI product. For each MODIS pixel, ECOCLIMAP-II gives a combination of vegetation types (patches or PFT) with their corresponding fractions. The algorithm takes the nearest MODIS pixel with a pure vegetation type to distinguish the contribution of each patch in the mixed pixel signature. The detail of the method is given by Faroux & al. (2013). This method has been briefly described in the introduction and in the presentation of the model (Sect. 2.1) within the next version of the paper: "Because of the low spatial resolution of MODIS, the LAI signatures of several

C6

vegetation types are often mixed in a pixel. An unmixing method is then used by Faroux & al. (2013). It uses the nearest unmixed pixels of each PFT present in the MODIS pixel considered to assess the contribution of each PFT in the LAI climatology."

Anonymous Referee #2: "Section 2.1 - not enough model details are given - which version of SURFEX is used ? ... Is ISBA includes includes a coupled stomatal conductance-photosynthesis scheme (A-gs version)"

Authors: We used SURFEX 7.3. ISBA is used in its standard version and not the A-gs one. The A-gs version has been tested with the AST option which includes two strategies of plant's response to water stress. It led to the same conclusions with few modifications of the monthly fluxes. These precisions have been added to the description of the model (Sect. 2.1).

Anonymous Referee #2: "Which type of water transfer scheme? Energy balance ?"

Authors: For the water transfer scheme, we used the force restore approach (Deardorff, 1977, included in ISBA by Mahfouf & Noilhan, 1996) with three soil layers (Boone & al., 1999). For the runoff calculation, we used the Variable Infiltration Capacity approach (Dumenil & Todini, 1992) to calculate a subgrid runoff even if the soil layers of the cell are not saturated. This approach has been included in ISBA by Habets & al., 1999. The energy balance scheme is a single source scheme, i.e. computing a unique surface temperature for the soil and the vegetation. It uses the concept of stomatal resistance introduced by Jarvis (1976). These precisions have been added in the section 2.1 and the new references with it.

Anonymous Referee #2: "what about irrigation, is it simulated by the model"

Authors: As said in the results and conclusion, the irrigation is not simulated by the model in this study. The first reason is that we do not have access to spatialized forcing of irrigation yet, neither in volume nor on the determination of irrigation area. The second reason is that without taking irrigation into account, we can isolate the effect of

C7

the LAI modification from the effect of adding irrigation. The third reason is also that there is no automatic module of irrigation for this version of ISBA yet. Currently, ISBA can simulate an automatic irrigation pattern only in the A-gs versions with interactive vegetation, i.e. with a simulated LAI. The irrigation issue is one of the main outcomes of this study and the manuscript has been modified to highlight it. This key point will be the main focus of our future work.

Anonymous Referee #2: "the reference for the ISBA pedotransfer function is not correct, use Noilhan, J. and Lacarrère, P.: GCM Grid-Scale Evaporation from Mesoscale Modeling, J. Climate, 8, 206–223, 1994"

Authors: We have replaced the previous reference (Masson & al., 2013) by the one you proposed.

Anonymous Referee #2: "page 4, line 3-5: the description of ECOCLIMAP-II is not accurate. No vegetation parameters are derived from satellite observations. Some parameters are fixed for each plant functional type. Other parameter or variables vary geographically with the type of ecosystem. This part must be properly edited.

Authors: As described by Faroux & al. (2013), the ecosystems (or cover) are deduced from a classification based on SPOT/VEGETATION Normalized Difference Vegetation Index, crossed with already existing land cover, soil and climate maps. Each LAI profile of each vegetation type of each cover is then deduced from the MODIS LAI product as briefly described above. This is the only things that are determined by satellite observations. The other parameters come from different sources as described in Masson & al. (2003). This part has been properly modified to be more accurate.

Anonymous Referee #2: "Section 2.2: -page 4, line 17: "non-irrigated rotation": this is not a correct term"

Authors: The term has been rectified: "The two main types of crops found in this area are irrigated summer crops such as maize or soy plants and rain-fed rotation crops

C8

such as wheat and sunflower plants."

Anonymous Referee #2: "The authors should provide a dedicated Discussion section. They should properly discuss the main outcomes of the work and discuss their limits. The issue of uncertainties need to be addressed: uncertainty in the measurements, uncertainty in the satellite imagery (registration . . .), uncertainty in the land surface model affecting the simulation of ET"

Authors: The results and conclusion has been revised to provide a dedicated discussion part, as you suggested. We discuss the fact that the Formosat-2 LAI allows distinguishing the actual phenologic cycle and particularly the agricultural practices that modifies this cycle like seeding, harvest or crop rotations. The impact on evapotranspiration is then analyzed, showing the limits of the unmixing algorithm of ECOCLIMAP-II LAI retrieval method. It also shows the issue of the lack of irrigation in SURFEX. The uncertainties issue is also tackled as we discuss about the measurement uncertainties on LAI and LE but also about the remote sensing acquisition uncertainties. The uncertainty related to the model is hard to assess but the local comparison gave us some clue about satisfying performances on the LE simulation outside of irrigation periods. The limitations of the work are also discussed. Especially, we present the limitations introduced by the cloud coverage and the revisit frequency. Finally, the perspectives on the hydrological routing and the introduction of an irrigation process are presented.

Anonymous Referee #2: "English : English must be carefully edited, I provide some examples here page 2 line 4: "vegetation cover present"! "present vegetation cover" page 2 line 5 " the more accurate"! " more accurate" page 2 line 6 "to improving"! "critical to improve" page 3, line 10 "rather than"! "instead of " check in the document the use of "the" page 3, line 9: vegetation type and LAI Page 4, line 4-5: "the ISBA"! "ISBA", Shorter sentences are needed"

Authors: We have corrected all these examples. We also shortened some sentences in the paper. We particularly paid attention to this in the sections that were edited

C9

or added. Anonymous Referee #2: "the title is too long, some suggestions: use Earth observation instead of remote sensing products use cropland instead of cultivated area use high spatial and temporal resolution"

Authors: The title has been modified as suggested.

Anonymous Referee #2: "acronyms must be defined"

Authors: We have defined all the acronyms that were not already defined.

Again, we greatly appreciate your constructive comments that helped us to improve the manuscript. We hope that we answered to all your concerns in this revision.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., doi:10.5194/hess-2016-661, 2017.

C10