Hydrology and Earth System Sciences Discussions

Interactive comment on "Integrating MODIS images in a water budget model for dynamic functioning and drought simulation of a Mediterranean forest in Tunisia" *by* H. Chakroun et al.

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Reponses to Referee#2 The authors thank the anonymous Referee#2 for his/her review of the manuscript and for his/her constructive comments that will help in the final version of the paper. We have provided answers to each point raised by the reviewer (designated as "C"); our response is designed as "R".

C1: This paper is fairly well written, it addresses an interesting topic that should be of

interest to HESS readers. Leaf Area index derived from MODIS was used in a water budget model that simulates evapotranspiration and soil water content. In my opinion, several aspects should be enhanced before its publication, mainly in relation to the analysis performed and the discussion. I suggest (if feasible) to add an analysis from the original SIERRA model (with a calculated LAI) as well as some information on how MODIS-LAI performed over the studied area.

R1: We have not considered to compare water budget results from the original SIERRA model (based on self-equilibrated leaf biomass) to results from our method (replacing this module by integrated remote sensing data of LAI) in order to avoid any interpretation of results variation that could be attributed to deviation between LAI model estimation and satellite LAI. For example in Brut et al. (2009) a whole study was dedicated to this issue discussing both uncertainties in the models and in satellite products. This is beyond the scope of our study since our objective was to detect the effect of inter-annual variability of LAI on water budget and on drought monitoring just by the use of satellite products; this was achieved by comparing water budget simulation results in two cases : LAI constant (e.g. mean of LAI-MODIS during the simulation year) and weekly LAI-MODIS.

C2 :General Comments: The paper reads like a technical report, both in terms of content and format. Please split it into more traditional sections (Introduction, Materials and Methods, Results, Discussions, Conclusions: : :).

R2: We consider to rewrite the paper according to these recommendations in the revised version.

C3: The introduction also requires some modification, some sentences are rather vague while others are really focused (e.g. equation of the fAPAR). You state that "The lack of such studies over South Mediterranean areas [: : :]" is the main motivation of your work. You should at least discuss in the introduction international projects such as the HYMEX (Hydrological cycle in the Mediterranean EXperiment) project, SICMED

(Surfaces et Interfaces Continentales en Méditerranée): : : Please see Szczypta el al. (2012, HESSD), Barbu et al. (2010, Biogeosciences) for more information on studies over the Mediterranean basin as well as on the use of land biophysical variables (such as LAI) in land surface model. A "State of the art" and a clear statement on the motivation of this study are missing.

R3: By "lack of such studies" we mean specifically water budget modelisation at regional scale in forested ecosystem in Tunisia compared to the same kind of studies conducted in agricultural areas in the south Mediterranean regions. In our bibliographic review, we focused on remote sensing integration (either vegetation indexes or LAI) into water budget models, and we had not expressly mentioned neither methods of LAI simulation by models nor their integration into water budget modelisation. The reference data used to validate LAI-MODIS were ground measurements and calibration with another source of image (see R8). We will consider the references mentioned above and we will add references dealing with comparison of remote sensing LAI to simulated LAI (e.g. Brut et al., (2009))

About the motivation of this study : first investigations of LAI product and profile analysis within different vegetation/soil zones (section 3.2) inspired our researches: as mentioned in the statement of the objectives (p 6255, L 15-18), our hypothesis is that temporal resolution of LAI-MODIS product (an image /8days) allows considering the interannual variability of LAI and consequently the refinement of water balance calculation and drought monitoring in our study site.

Brut, A., RÂĺudiger, C., Lafont, S., Roujean, J.-L., Calvet, J.-C., Jarlan, L., Gibelin, A.-L., Albergel, C., Le Moigne, P., Soussana, J.-F., Klumpp, K., Guyon, D., Wigneron, J.-P., and Ceschia, E.: Modelling LAI at a regional scale with ISBA-A-gs: comparison with satellite derived LAI over southwestern France, Biogeosciences, 6, 1389–1404, doi:10.5194/bg-6- 1389-2009, 2009.

C4: Slide 6255, I am not sure to understand what you mean by '[: : :] framework for

satellite data (MODIS-LAI) integration [: : :]', are you talking about the method? From what I understood, what you do is more or less a direct insertion of MODIS-LAI (?) into your water budget model.

R4: What we mean by "Framework" is the stages for integrating dynamic vegetation driven by LAI-MODIS into the model. It is not related to any complex assimilation methods into the model, it rather encompasses steps of satellite images processing, including validation and calibration (see R8 for details about LAI-MODIS calibration).

C5 :Slide 6255, the general process and equation of the model should be in the text, giving them in a Table make them very hard to follow.

R5 : We will integrate equations into the text in the section "Material and Methods'

C6: Slide 6257, Output from the original SIERRA model with a calculated LAI are required to see (i) the performance of the SIERRA model on your test site,

R6 : see R1 as response for original SIERRA model outputs

Validation issue and performance of the model : we agree that validation issue is crucial for any modelisation. As mentioned in P6267-Line 22, the site begins to be equipped by a ground station of transpiration based on sap flow densities measurements during a complete vegetative season. In the revised version we will include a comparison of simulated results to measured actual evapotranspiration for 2009 season; this will allow to estimate deviation between simulations and ground measurements. That said, regarding our study objectives (2) (P 6255, Line 15 : Despite the coarse spatial resolution of LAI-MODIS (1 km), what kind of improvements of water budget modelisation and drought monitoring), our work focuses on relative comparisons of dynamic-LAI scenario to constant-LAI one, and not absolute comparison of model outputs to measured ones. Even if the model SIERRA had not yet been calibrated in the study site, we considered that using it in this perspective can be fairly justified.

C7: (ii) the added value of your method (if there is one?). I believe that it is a pre-

requisite, of greater interest than the sensitivity study you proposed in section 4.2.

R7 : The added value of our work is to evaluate whether or not vegetation dynamic (driven by MODIS sensor in measuring LAI) has a perceptible effect on water budget outputs (evapotranspiration, soil water content) and consequently water stress index and drought monitoring at regional scale in the study region (North of Tunisia). Thus, considering objective (2) (P6255, Line 15), the sensitivity analysis in basically a comparative analysis between model outputs from two scenarios, one considering vegetation as dynamic during the year (LAI-MODIS), the other considering a constant value of LAI along the year. At the same time, this investigation was motivated by previous works in Mediterranean ecosystems (P 6265, Line 4 to 7) conducted at local scale and showing that increase of LAI is accompanied by an increase of drought stress. Then, we attempt to verify the validity of this result at regional scale.

C8: Slide 6260: Please give more indication on how LAI-MODIS performed in your studied area.

R8: Ground measurements of LAI were based on homogeneous plots of vegetation (details of measurements method and statistics will be added to the revised version). Besides, we will add a comparison of these in situ measurements to a SPOT image taken at the same period (May-June 2006), this allows to make a "ground truth" LAI map based jointly on measurements and a 20 m spatial resolution satellite image.

The issue of MODIS coarse resolution and validation to ground truth has been raised in the paper. Despite the 1km resolution of LAI-MODIS product, we showed that comparison of LAI ground measurements to LAI-MODIS for NDVI < 0.7 is quite acceptable (p6260, L 27-28, P 6261, line 1-5). However, the problem of validation of LAI-MODIS arises from highly overestimated values for high biomass pixels (NDVI > 0.7) limiting use of this product. To overcome this, and as suggested in the discussion (P 6266, line 21), we will perform in the revised version a correction of LAI-MODIS as follows :

(1) Production of a "ground truth LAI map" from analysis of the relation between NDVI

(from SPOT taken in june 2006) and measured LAI . This map is called LAI-SPOT. (2) Aggregation of LAI-SPOT from 20m to the 1km resolution (we call this image LAI-SPOT-AG) (3) Comparison pixel by pixel LAI_SPOT-AG to LAI_MODIS. (4) Calibration of LAI-MODIS images by LAI-SPOT-AG.

C9: Section 2.1 describes the general component of the model but their sources are given in section3. I believe it should be together. A specific section should be dedicated to the conclusion.

R9: In the revised version, we will review the whole structure of the paper considering all suggestions.

C10 : Specific Comments Slide 6252, I believe acronyms used in an abstract should be avoided and if unavoidable, be defined. Please check which guidelines HESS applies to solve this issue. Slide 6253, L.13-16: Please rephrase sentence. L.20-22: It is one method amongst others: : : Slide 6255, L.7: Please give acronym for ASTER. L.15-17: Please rephrase sentence. Slide 6257, L.9-10: Please use 'Saxton et al., 1986, 2006'. Slide 6260, L.8-10: Any idea about the quality of Rg from ARPEGE Circulation model? Slide 6263, L.12: Please give acronym for STR. Even if I recognize the quality if the figures, some of them are difficult to read (e.g., Fig.1, 6). What are the units on Fig.2? LAI in m2m-2.

R10 : We will consider all these specific comments in the revised version

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 9, 6251, 2012.