**“Suitability of modelled and remotely sensed essential climate variables for monitoring Euro-Mediterranean droughts”**
**by C. Szczypta et al.**

# Cover letter to the editor

10 March 2014.

Dear Dr. Sato Hisachi,

The authors’ response to the comments of the two anonymous referees (see below) has been published on the GMDD web site.

The points brought forward by the two referees will lead to an improvement of the manuscript. The authors would like to submit a revised version of the paper for final publication in GMD.
All changes relative to the published GMDD paper are detailed in the pdf of the new manuscript. They include all the response elements given by the authors in response to the reviewers’ comments (yellow and green for Reviewer 1 and 2, respectively).
In particular, the content of Sect. 4.3 was redistributed in Sections 2, 3 , and 4, and a new Figure (Fig. 8) was added.

Figures

Figure 8 was added.

References

Two additional references were added (Rebel et al. 2012 and Loew et al. 2013).

Sincerely,
JC Calvet, C. Szczypta.

# Response to Reviewer #1

The authors thank the anonymous reviewer #1 for his/her review of the manuscript and for the helpful comments.

1.1 [I believe that the manuscript should be accepted subject to minor revisions with respect to its structure and the rephrasing of some part of the text. ]

**RESPONSE 1.1**
The suggested minor revisions will be made accordingly in the final version of the manuscript.

1.2 [Abstract: You define some acronyms (LAI, SSM, LGP) but not others (ORCHIDEE, ISBA-A-gs) Please double check GMD(D) policy for acronyms. ]

**RESPONSE 1.2**

Yes, all the acronyms will be defined in the abstract of the final version of the manuscript.

ORCHIDEE: *ORganizing Carbon and Hydrology In Dynamic EcosystEms.*

ISBA-A-gs: *Interactions between Soil, Biosphere and Atmosphere, $CO_2$-reactive (A-gs).*

1.3 [L1 "Two new remotely sensed Leaf Area Index (LAI) and Surface Soil Moisture (SSM) satellite products [...]" It might be fair to use 'satellite-derived' products .]

**RESPONSE 1.3**

Yes, "satellite" will be replaced by "satellite-derived" here.

1.4 [L7 "The leaf onset and the Length of the vegetation Growing Period (LGP) are derived from the satellite-derived LAI and from the modelled LAI." could be rephrased by "The leaf onset and the Length of the vegetation Growing Period (LGP) are derived from both the satellite-derived and modelled LAI." ]

**RESPONSE 1.4**

Yes, this sentence will be reworded accordingly.

1.5 [Introduction: P.5554, L.25, Please define what is an Essential Climate Variable. P.5555, L.3-11, I am missing a transition here, while most of the introduction is fairly well written, the paragraph on LAI reads more as a technical point. Please rephrase the beginning of the Introduction section.]

**RESPONSE 1.5**

The beginning of the introduction section could be rephrased as:

"The Global Climate Observing System (GCOS) has defined a list of atmospheric, oceanic, and terrestrial Essential Climate Variables (ECVs) which can be monitored at a global scale from satellites. The terrestrial ECV products consisting of long time series are needed to evaluate the impact of climate change on environment and human activities. They have high impact on the requirements of the Intergovernmental Panel on Climate Change (IPCC). Over land, new ECV products are available and they can be used to characterize extreme events, such as droughts.
Leaf Area Index (LAI) is one of the terrestrial ECVs related to the vegetation growth and senescence. Monitoring LAI is essential for assessing the vegetation trends in the climate change context, and for developing applications in agriculture, environment, carbon fluxes and climate monitoring. LAI is expressed in $m^2$ $m^{-2}$ and is defined as the total one-sided area of photosynthetic tissue per unit horizontal ground area."

1.6 [Data and Methods: P.5557, L.5-12, This paragraph should introduce section 2 (?) No transition at all between the different sentences, it seems that just 'bullets' are expressed. P.5557, L11-12, "From 1991 onward, SSM observations from active (ERS-1/2, ASCAT) and passive (SSM/I, TMI, AMSR-E) microwave sensors are available." OK, I understand that you will use them latter on in the manuscript but as it is, this sentence is useless. Do you mean that additionally to the ESA-CCI SSM data set this study makes use of SSM observations from active (ERS-1/2, ASCAT) and passive (SSM/I, TMI, AMSR-E) microwave sensors over yyyy-yyyy and available from...If you prefer you could also dedicate a sub-section to all the soil moisture data set used in this study. ]

**RESPONSE 1.6**

This paragraph could be reworded as:

"In this study, several data sets (either model simulations, atmospheric variables, or satellite products) were produced or collected, over the Euro-Mediterranean area. In order to force the two LSMs simulations of SSM and LAI (Sect. 2.1), the ERA-Interim atmospheric variables are used. The ERA-Interim data are available on a reduced Gaussian grid (of about 0.7° x

0.7°) and projected to the 0.5° x 0.5° grid of the LSM simulations (Szczypta et al., 2012). The 1991-2008 18 yr period is considered in this study, as in Szczypta et al. (2012). During this period, SSM products from both active (ERS-1/2, ASCAT) and passive (SSM/I, TMI, AMSR-E) microwave sensors are available and can be combined (Sect. 2.2), together with LAI products (Sect. 2.3). In order to compare the LSM simulations with the satellite products, the latter are aggregated on the same 0.5° x 0.5° grid using linear interpolation and averaging techniques."

1.7 [P.5557-5558, while you provide acronyms for SECHIBA, STOMATE, LPJ, you do not provide that of ORCHIDEE (or ISBA-A-gs). ]

**RESPONSE 1.9**

ORCHIDEE and ISBA-A-gs acronyms will be detailed in the new version of the manuscript (see response 1.2.)

1.8 [2.1.3 Design of the simulation: P.5559, L19-20, after a quick look to Szczypta et al., 2011, it seems that the underestimation of precipitation in ERA-Interim was observed over France. How realistic is to correct the rain over your much bigger domain? ]

**RESPONSE 1.8**

The underestimation of precipitation in ERA-Interim was observed over France by Szczypta et al. (2011) and over the Euro-Mediterranean area by Szczypta et al. (2012). In the latter study, the correction of the precipitation was applied over the whole Euro-Mediterranean area and indirectly validated using river discharges simulations and observations.

1.9 [2.3 GEOV1 LAI: P.5561, L.7-8, "The GEOV1 scores are better than those obtained by other products." such as?]

**RESPONSE 1.9**

The GEOV1 LAI scores are better than those obtained by other products such as MODIS c5, CYCLOPES v3.1, and GLOBCARBON v2.

1.10 [2.4.1 should be Surface Soil Moisture instead of ’SSM’ only ; 2.4.2 should be Leaf Area Index instead of ’LAI’ only. "Three metrics are calculated to characterize LAI seasonal and interannual variability [...]" ]

**RESPONSE 1.10**

Yes. Will be reworded accordingly.

1.11 [3 Results: P.5564, L.2 'squared correlation coefficients', coefficient of determination (?) [as P.5569] ]

**RESPONSE 1.11**

Yes, the coefficient of determination corresponds to the squared correlation coefficient. For the sake of consistency, only one term will be used.

1.12 [3.2 Simulated and observed phenology: Could Authors provide an indication of the ability of GEOV1 product to capture observed LAI amplitude (if any evaluations are available)? ]

**RESPONSE 1.12**

The direct validation of the GEOV1 LAI product by Camacho et al. (2013) is based on an ensemble of ground observations at 30 sites but it does not completely address the seasonality of LAI as for a given site, LAI observations are available at only one or very few dates.

1.13 [3.3 Representation [...] P.5565, sometimes $r^2$ is used and sometimes it is r, please be consistent.]

**RESPONSE 1.13**

Squared correlation coefficient plots are used in this study when all the corresponding r values are greater or equal to zero. When r presents negative values, r is plotted instead of the square correlation coefficient.

1.14 [4.1. Representation of soil moisture: L.1, first sentence does not reflect the title of the subsection. Also this sentence is not clear (to me), do you mean that the difficulty of the model to represent LAI inter-annual variability can be partly explained by [...] (?) ]

**RESPONSE 1.14**

Yes. The first sentences of this section could be reworded as:

"In the two LSMs considered in this study, soil moisture impacts the LAI seasonality and interannual variability. The interannual variability of the simulated LAI is often driven by changes in the soil moisture availability, which for the soil models of the versions of ORCHIDEE and ISBA-A-gs used in this study consist of rather simple parameterizations that are unable to simulate detailed soil moisture profiles including the ability of different root layers in the profile to take up water. Therefore, while the difficulty in representing the modelled LAI interannual variability, as illustrated in Sects. 3.3 and 3.4, can be partly explained by shortcomings in the phenology and leaf biomass parameterizations, another factor is the inadequate simulation of root-zone soil moisture. For example, [...]"

1.15 [4.2 Representation of LAI: P.5568, the algorithm used to produce GEOV1 LAI should be indicated in section 2.3 ]

**RESPONSE 1.15**

Yes, the description of GEOV1 could be moved to Sect. 2.3.

1.16 [Section 4.3 could be presented in section 3 'Results' ]

**RESPONSE 1.16**

Yes, the content of Sect. 4.3 could be redistributed in Sections 2, 3 , and 4.

1.17 [5. Conclusions: P.5572, L.13, "[...] and highlighted the regions where the ESA-CCI product can be improved." But did not mention how to improve this product .]

**RESPONSE 1.17**

The ESA-CCI SSM could be improved by revising the procedure for blending the active and passive microwave products.

1.18 [Figure 3 (also 4), it is not clear to me if the white areas have a r value close to 0 or if no data are available for the evaluation. ]

**RESPONSE 1.18**

In both Figs. 3 and 4, white areas correspond to r values lower (higher) than 0.1 (-0.1).

1.19 [Figure 8, considered period should be indicated in the caption. ]

**RESPONSE 1.19**

Yes, the considered period (1991-2008) will be indicated in the caption.

# Response to Reviewer #2

2.1 [First of all, the originality and/or advantage of this study are not clear. I know that two models have been assessed their accuracies on LAI and SSM (only for ISBA), individually so far. I'd like to know more precisely about the originality and/or advantage for this model validation when compared to previous model validation papers on both models.]

**RESPONSE 2.1**

This study complements the joint evaluation of the ORCHIDEE and ISBA-A-gs land surface model performed by Lafont et al. (2012) over France using satellite-derived LAI, as it is expanded to the Euro-Mediterranean domain. A 18 yr time period is considered against a 8 yr period (2000-2007) in Lafont et al. (2012). The capacity of the two models to represent the interannual variability of the vegetation growth and the impact of extreme events such as the 2003 heat wave is assessed. Finally, the synergy between SSM and LAI is investigated using the satellite products and the ISBA-A-gs model.

2.2 [Although the satellites data of this study are newly prepared long-term record of LAI and SSM, it does not guarantee their higher accuracies compared to previously organized other data sources.]

**RESPONSE 2.2**

The direct validation of the GEOV1 LAI product performed by Camacho et al. (2013) is based on an ensemble of ground observations at 30 sites but it does not completely address the seasonality of LAI as for a given site, LAI observations are available at only one or very few dates. Based on these observations, Camacho et al. (2013) show that the GEOV1 LAI scores are better than those obtained by other products such as MODIS c5, CYCLOPES v3.1, and GLOBCARBON v2.

Regarding SSM, as far as we know, the ESA-CCI SSM product is today the only multi-decadal SSM dataset derived from satellite observations. Loew et al. (2013) have assessed this product and showed that the agreement with other soil moisture datasets from modeling studies as well as with rainfall data is generally good.

**REFERENCE:**

Loew, A., Stacke, T., Dorigo, W., de Jeu, R., and Hagemann, S.: Potential and limitations of multidecadal satellite soil moisture observations for selected climate model evaluation studies, Hydrol. Earth Syst. Sci., 17, 3523–3542, 2013.

2.3 [Especially, no validation of SSM for ORCHIDEE reduces the value of this paper. I think that ORCHIDEE also has soil moisture outputs, which could be converted into similar soil moisture variable to be compared to satellite SSM. So I hope that you can show us the SSM analyses with ORCHIDEE's estimation. If it's impossible, you have to mention more precisely the reason why ORCHIDEE could not produce the SSM value.]

**RESPONSE 2.3**

An attempt was made by Rebel et al. (2012) to compare the soil moisture simulated by ORCHIDEE with the AMSR-E SSM product. They concluded that the shallow soil moisture estimates they derived from the ORCHIDEE simulations were not an explicit representation of SSM and could not be compared with the AMSR-E SSM product. Instead, they compared the AMSR-E SSM with the root-zone soil moisture simulated by ORCHIDEE, and they observed that the satellite-derived SSM had a much faster reaction time and a much shorter characteristic lag-time than the simulations. This can be explained by the shallow penetration depth (<5 cm) of the C-band microwave signal measured by AMSR-E, which is not representative of deep soil layers.

**REFERENCE:**

Rebel, K. T., de Jeu, R. A. M., Ciais P., Viovy, N., Piao, S. L., Kiely, G., and Dolman, A. J.: A global analysis of soil moisture derived from satellite observations and a land surface model, Hydrol. Earth Syst. Sci., 16, 833–847, doi:10.5194/hess-16-833-2012, 2012.

2.4 [The comparability of satellite-derived SSM data has not been that much discussed. The satellites detect the SSM only for first several centimeters, which does not necessarily match with the depth for which the plants will take up the water for growth and the models take into account. So it will invoke the incomparability between model and satellite. This issue is mainly from insufficient explanation on which soil layer with how large depth of ISBA-A-gs the authors took up for comparison.]

**RESPONSE 2.4**

In the Introduction section, we made clear that the sensing depth of microwave remote sensing observations is limited to the first centimetres of the soil surface. The definition of SSM in ISBA-A-gs is given in Table 1. We acknowledge that this could be better emphasized/discussed in the text.

2.5 [Minor thing is that the authors change the order of explanation on two variables: SSM and LAI. In Introduction you explained firstly about LAI and secondarily about SSM. But, in Result and Discussion section, you did it firstly about SSM and secondarily about LAI.]

**RESPONSE 2.5**

Yes. The LAI paragraph in the Introduction could be moved after the SSM paragraph.

2.6 [Also you put the figures in the panel from Fig 6 to Fig 11 in the order of ISBA, ORC, GEOV1 or ORC, ISBA, GEOV1, or GEOV1, ISBA, ORC, separately. It is not intuitively easy to understand. You have to unify them.]

**RESPONSE 2.6**

Yes. The figures could be harmonized using the GEOV1, ISBA-A-gs, ORCHIDEE sequence.

2.7 [Page 5554, Line 1-5: I do not think that the authors have investigated deeply the drought effect on vegetation this time. You rather did the validation between model and satellite products, meaning that you explored how nicely the models represent the seasonal and interannual changes in LAI associated with SSM (though only for ISBA).]

**RESPONSE 2.7**

Yes. This part of the first sentence of the Abstract ("to investigate how recent droughts affected vegetation over the Euro-Mediterranean area") could be reworded and/or moved to another part of the Abstract.

2.8 [Page 5556, Line 23-24: Is it right? I think that ORCHIDEE also has several soil layers, which definitely can produce the variables concerning soil moisture. You have to explain the reason why you excluded ORCHIDEE in that analysis more precisely.]

**RESPONSE 2.8**

Again, part of the explanation is given in Table 1. We acknowledge that this could be better emphasized/discussed in the text.

2.9 [Page 5557, Line 6-8: I have no objection on this projection of climate forcings onto half degrees although the spatial and temporal variabilities of climate data should be more or less smoothed when projected onto finer resolutions. But, I like to know why you had to do it. I guess that it is because ORCHIDEE and/or ISBA have other ancillary data only on half degrees. Anyway write the reason.]

**RESPONSE 2.9**

In fact, we mean that the ERA-Interim atmospheric variables used to run the LSMs are available on a 0.5° × 0.5° grid (Szczypta et al., 2012).

2.10 [Page 5557, 2.1.1 and 2.1.2: I think that it is easier for readers to understand when you explain the models from ISBA but from ORCHIDEE because hereafter you address the result and make the figures in the order of ISBA, ORCHIDEE normally.]

**RESPONSE 2.10**

Yes, the sequence of model description in Sect. 2.1 could be revised.

2.11 [Page 5557, Line 21-: What's the temporal resolution? Write it.]

**RESPONSE 2.11**

The two models are driven by the 3 hourly atmospheric variables from the bias-corrected ERA-Interim and perform half-hourly simulations of the surface fluxes, of soil moisture and of surface temperature. LAI is produced at a daily time step for each Plant Functional Type (PFT) present in the grid-cell. Daily mean SSM values are produced for each PFT. The grid-cell simulated LAI (SSM) is the average of the PFT-dependent LAI (SSM) multiplied by the fractional area of each PFT.

2.12 [Page 5558, Line 20, Did you compare the soil moisture of this ‘thin surface layer’ to the SSM by ESA-CCI? Clarify it.]

**RESPONSE 2.12**

In this study, only the surface atmospheric variables of ERA-Interim are used.

2.13 [Page 5559, Line 6-8: ISBA has been already assessed its accuracy on LAI estimation, and ORCHIDEE also has been checked that several times previously. So what is the point of this research?]

**RESPONSE 2.13**

This study complements the joint evaluation of the ORCHIDEE and ISBA-A-gs land surface model performed by Lafont et al. (2012) over France using satellite-derived LAI, as it is expanded to the Euro-Mediterranean domain. A 18 yr time period is considered against a 8 yr period (2000-2007) in Lafont et al. (2012). The capacity of the two models to represent the interannual variability of the vegetation growth and the impact of extreme events such as the 2003 heat wave is assessed. Finally, the synergy between SSM and LAI is investigated using the satellite products and the ISBA-A-gs model.

2.14 [Page 5560, Sec. 2.2: I like to know the accuracy of this SSM dataset and how deeply in the soil it can detect soil moisture. Explain it. Also I like to know the original temporal resolution of satellite detection of SSM.]

**RESPONSE 2.14**

Yes, we could recall here that the sensing depth of microwave remote sensing observations is limited to the first centimetres of the soil surface. Loew et al. (2013) have assessed this product and showed that the agreement with other soil moisture datasets from modeling studies as well as with rainfall data is generally good. The ESA-CCI SSM temporal and spatial coverage is much better after 1990 than before but is limited at high latitudes due to snow cover and frozen soil conditions (Loew et al. 2013).

2.15 [Page 5563, Line 25-Page 5564, Line 1: It also shows that 2003 year does not affect that much on consistency in correlation between ESA-CCI and ISBA. More than that, it also shows that AMSR-E has quite lower correlations with ISBA, which suggests that AMSR-E SSM are quite different with other SSM satellite data sources, and that ISBA may provide the reduced accuracy on SSM estimation when AMSR-E products are assumed to be more accurate than other SSM sources due to its latest technic for detection. Another thing is that this part should be in Discussion.]

**RESPONSE 2.15**

Yes, Fig. 3 and the top sub-figures of Fig. 4 are similar over western Europe, although the extreme 2003 year has more weight in the time series considered in Fig. 4. In Sect. 4.4, it could be mentioned that SSM simulations could be used to improve the blending of the active and passive microwave products.

2.16 [Page 5564, Line 17-19: How do you count the values in terms of month? Because the days of month are different for each month, I feel that it is strange to use the unit of months to count the LGP. I think that ‘days’ is good unit enough for expressing the LGP.]

**RESPONSE 2.16**

Yes, this sentence could be rewritten as:

**"On average, ORCHIDEE gives relatively high LGP values (180 ± 28 day), compared to ISBA-A-gs and GEOV1 (138 ± 41 day and 124 ± 44 day, respectively). "**

2.17 [Page 5564, Line 26: I am not so sure that there is a 1 month lag in leaf onset. ISBA appears 1 month lag in max LAI to GEOV1, but the timing of taking-off the bottom line is not that so clearly delayed to GEOV1 in my view. Along with the definition of leaf onset, it could be possible to have small or no delay when you describe the map of Fig 6.]

**RESPONSE 2.17**

Yes, a new figure showing leaf onset and LGP differences in days could be added.

2.18 [Page 5568, Line 12: improving?]

**RESPONSE 2.18**

Yes, "improve" should be replaced by "improving".

2.19 [Page 5588, Figure 6: I think that the interval of colors would better be shorter than 1 month. Also I recommend you to put another Diff (ORC - GEOV1 and ISBA - GEOV1) figures. The order of panels of Fig6&7 are different to that of Fig. 8&9, and that of Fig 10&11. I prefer the order of ISBA, ORC, GEOV1 or GEOV1, ISBA, ORC for every figure as same order as you explained in the text.]

**RESPONSE 2.19**

Yes, a new figure showing leaf onset and LGP differences in days could be added. The figures could be harmonized using the GEOV1, ISBA-A-gs, ORCHIDEE sequence.

2.20 [Page 5589, Figure 7: The interval of colors should be shorter than 1 month to know the gradual change in value. Could be 2 weeks or 1 week.]

**RESPONSE 2.20**

Yes, a new figure showing leaf onset and LGP differences in days could be added.