Climate Modelling User Group

Interim Report for OWP5.3

Impact of integrating CCI data in the ISBA land surface model

Centres providing input: Météo-France

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CMUG CCI+ Deliverable 5.3.3

Interim Progress Report

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Impact of integrating CCI LAI data in the ISBA land surface model

1. Purpose and scope of this report

This document is an interim report dedicated to the impact of different leaf area index (LAI) products on the analysis with the LDAS-Monde assimilation system using the Soil, Biosphere, Atmosphere (ISBA, Noilhan and Mahfouf 1996) land surface model (LSM). The focus is on the implementation of the novel product CCI-LAI, which aims to combine the LAI derived from multiple sensors over a period into a single product (Swinnen et al. 2025).

We compare the performance of this novel product against the established LAI products from GEOV2-AVHRR (Advanced Very High-Resolution Radiometer; https://www.theia-land.fr/en/blog/product/series-of-vegetation-variables-avhrr) and CLMS (Copernicus Land Monitoring Service; https://land.copernicus.eu/en/products/vegetation/leaf-area-index-300m-v1.0). So far, CCI-LAI is available in a not-final version (v2), where only three sensors are combined. Due to the retrieval algorithm, which is based on the radiative transfer model 4SAIL2 (Verhoef and Bach 2007), vegetation clumping is not taken into account and, thus, only effective LAI is obtained. We convert to true LAI using an external data set for the clumping index. The CCI-LAI data is currently available over most of Europe with the exception of Northwest Russia and Iceland.

For the verification of the LAI assimilation, we compare the analyses with one of LAI observational data sets as reference, in future as well with an independent product of the Gross Primary Production (GPP from FLUXCOM), which is a measure directly related to the LAI. In this fashion, we determine the impact of the different products on the analysis with respect to each other and independently.

2. Approach for assessing the impact of LAI observations in ISBA

The assimilation system is set up for the European domain at a spatial resolution of 0.25 x 0.25° for the period 2010 to 2022. As LSM we employ the CO2-responsive ISBA-A-gs model (Calvet et al. 1998), which is forced by the ERA5 model.

Our goal is to work with the most recent release of the SURFEX (Masson et al. 2013) modelling platform (v9.1) and the ECOCLIMAP-SG physiographic database, for the moment, an outdated SURFEX version has been used only, more experiments are in preparation (Table 1). In addition, an experiment without assimilation (open loop) is run.

Table 1: *Assimilation experiments. OL stands for open-loop, DA for data assimilation.*

Experiment name	Assimilated LAI data set	Data availability	SURFEX version	status
OL_90	no assimilation	2010 - 2022	v9.0	finished
OL_91	no assimilation	2010 - 2022	v9.1	ongoing
DA_90_CLMS	CLMS_V1	2014 - 2026	v9.0	finished
DA_91_CLMS	CLMS_V2	2014 - 2026	v9.1	ongoing
DA_90_AVHRR	GEOV2-AVHRR	1981 - 2021	v9.0	finished
DA_91_AVHRR	GEOV2-AVHRR	1981 - 2021	v9.1	ongoing
DA_91_CCI_eff	CCI (effective)	2000 - 2020	v9.1	ongoing
DA_91_CCI_true	CCI (true)	2000 - 2020	v9.1	ongoing

3. CMUG OWP5.3 results

3.1 The CCI-LAI data set

As mentioned before, the data set is not yet in its final state. We recently received the version 2 data set and are currently working with this. A main issue is that the data set only provides effective LAI, i.e., we convert it ourselves into true LAI. This is achieved by dividing by the Clumping Index (CI) derived from MODIS.

This CI data seems to be inconsistent, for a CI the data range is expected to be between 0.3 and 1, but this is not the case for data before 2018. After a recommendation from the CCI-LAI developers, we are averaging the monthly CI over several years using an exponential weighted mean function. This procedure allows for more temporal consistency, nevertheless, the true LAI values obtained are still not in agreement with the LAI from GEOV2-AVHRR. In particular, the converted true CCI-LAI is too low, on average (shown for one example month, July 2011, in Fig. 1). At the same time, the converted true CCI-LAI exhibits a rather large number of values larger than 6 m^2m^{-2}, that do not seem realistic. The large values are not visible in Fig. 1 because they fall within the tail of the distribution. . Figure 2 presents monthly mean time series of the 3 LAI retrievals. Although the converted true CCI-LAI is larger than the original effective LAI, it is still much smaller than the GEOV2-AVHRR. Figure 3 illustrates the inconsistency of the clumping index – although we applied an exponentially-weighted moving average over 9 years. The change in the amplitude of the CI seasonal cycle after 2018 is clearly visible.

Our results are similar to the findings of Verger et al. 2025 who studied the effective LAI of the C3S product and found that it does not agree well with similar products.

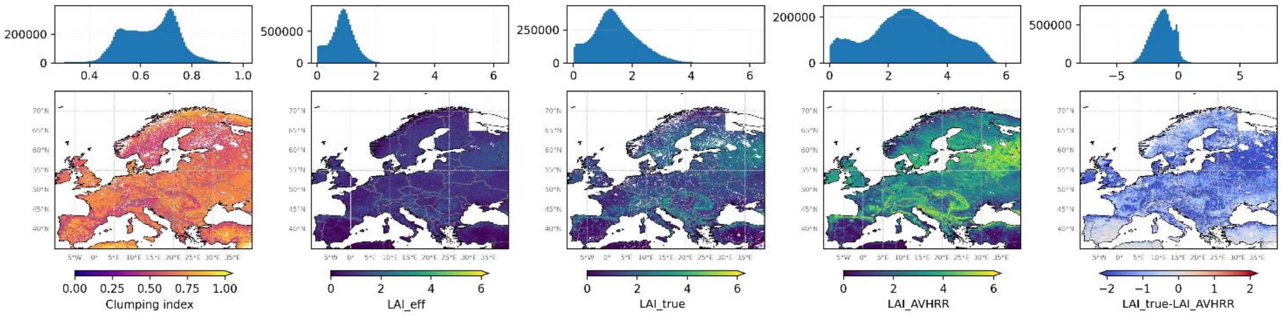

Figure 1: Histograms (top row) and maps (bottom row) showing the distribution of, from left to right: the clumping index; the effective CCI-LAI; the converted true LAI of the CCI-LAI product; the GEOV2-AVHRR LAI, and the difference of the two latter for July 2011 (from left to right).

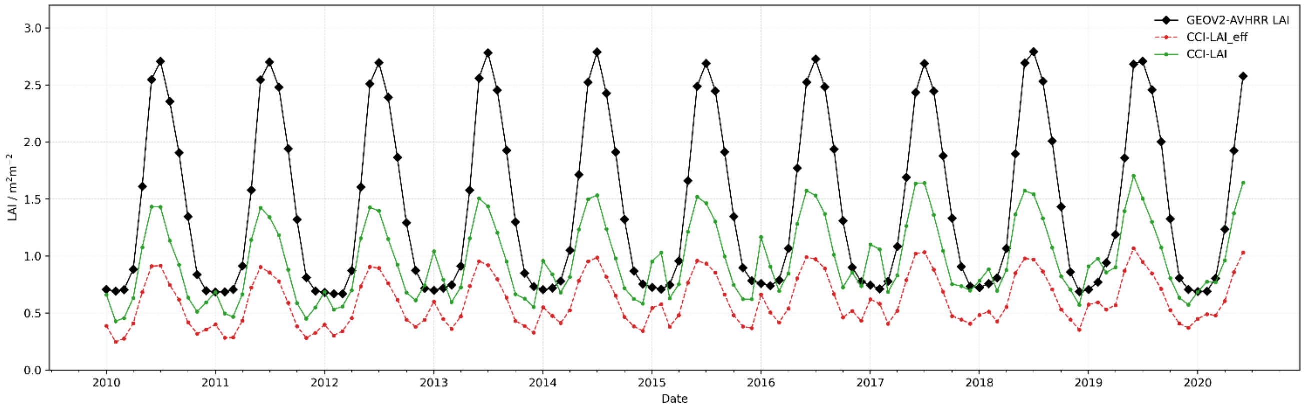

Figure 2: Time series of GEOV2-AVHRR-LAI (black), effective CCI-LAI (red), and converted true CCI-LAI (green). The data was spatially averaged over the whole domain.

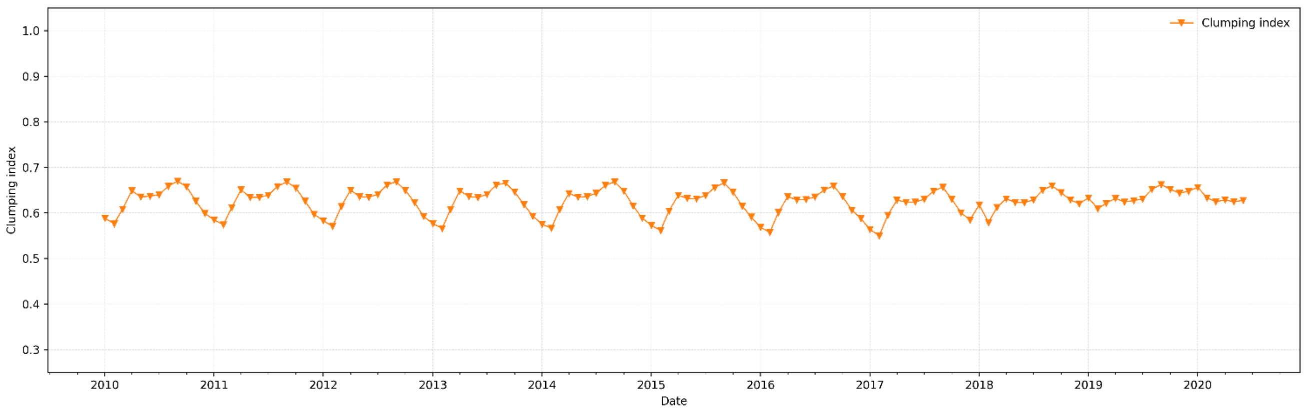

Figure 3: Time series of clumping index. The data was spatially averaged over the whole domain.

3.2 LDAS-Monde analyses – impact on LAI

At the midpoint of the study, results using SURFEX v9.0 are available and are reported on here. Experiments making use of the most recent v9.1 have been launched. We compare the LAI analyses of the DA_90_CLMS and the DA_90_AVHRR experiment with the GEOV2-AVHRR-LAI observations.

In terms of Root Mean Square Error (RMSE, Figs. 4 and 5), we yield an improvement over the whole domain with traces of a slight degradation at the Northern and Southwestern edge of the domain for the DA_90_CLMS experiment, which could be due to insufficiently treated wetlands in the observations and also to the fact that the CLMS LAI analysis is compared to GEOV2-AVHRR. In Fig. 5, improvement is more continuous because the comparison is made with the same product we assimilated.

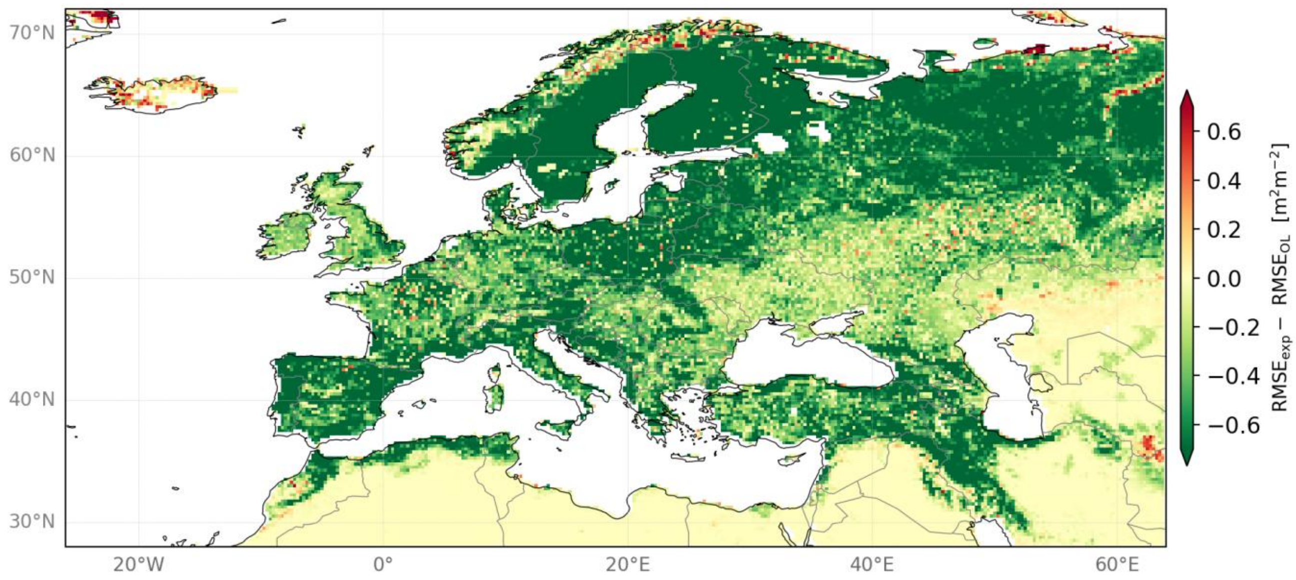

Figure 4: The RMSE difference between experiment and open loop for DA_90_CLMS for the whole time period.

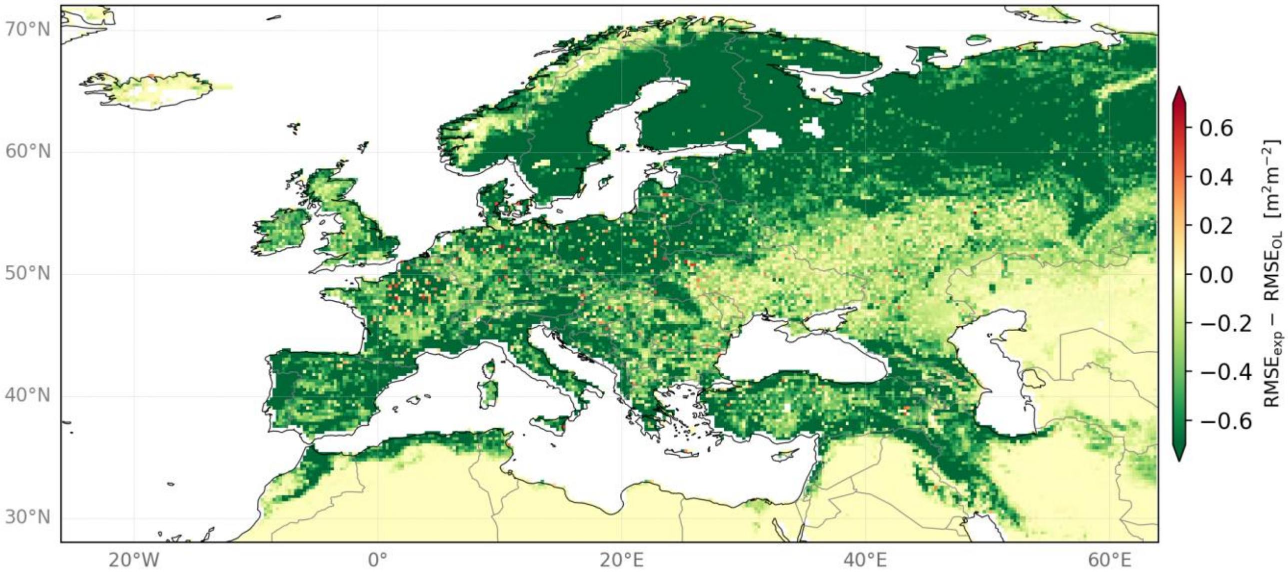

Figure 5: The RMSE difference between experiment and open loop for DA_90_AVHRR for the whole time period.

4. Conclusions

With the aim to compare the performance of different LAI products within the assimilation system LDAS-Monde, we are evaluating three different products: GEOV2-AVHRR, CLMS, and CCI. Whereas the first two products are established and can be assimilated directly, the latter in its current state requires some preprocessing like the conversion from effective to true LAI. The obtained LAI values still deviate significantly from the reference LAI (AVHRR) and more investigation is needed to improve on the final product.

For the established products, we have run LDAS-Monde for the European domain between 2010 and 2022 using SURFEX v9 and ECOCLIMAP-SG. Both LAI products improve the LAI compared to the open loop run. Nevertheless, the LAI degrades during the growing season. Since we suspect inconsistencies due to a change in the SURFEX, we are currently repeating all experiments using SURFEX v9.1.

5. References

Calvet, Jean-Christophe, Joël Noilhan, Jean-Louis Roujean, et al. 'An Interactive Vegetation SVAT Model Tested against Data from Six Contrasting Sites'. *Agricultural and Forest Meteorology* 92, no. 2 (1998): 73–95. https://doi.org/10.1016/S0168-1923(98)00091-4.

Masson, V., P. Le Moigne, E. Martin, et al. 'The SURFEXv7.2 Land and Ocean Surface Platform for Coupled or Offline Simulation of Earth Surface Variables and Fluxes'. *Geoscientific Model Development* 6, no. 4 (2013): 929–60. https://doi.org/10.5194/gmd-6-929-2013.

Noilhan, J., and J. F. Mahfouf. 'The ISBA Land Surface Parameterisation Scheme'. *Global and Planetary Change* 13, nos 1–4 (1996): 145–59.

Swinnen, Else, Kris Vanhoof, Jorge Sanchez, Fernando Camacho, and Simon Blessing. *CCI+ Vegetation Parameters*. 2025.

Verger, Aleixandre, Marie Weiss, and Frédéric Baret. 'GEOV2-AVHRR: Continuous and Consistent Time Series of Global Leaf Area Index and Fraction Absorbed PAR from 1981 to 2022'. *Remote Sensing of Environment* 331 (December 2025): 115029. https://doi.org/10.1016/j.rse.2025.115029.

Verhoef, Wout, and Heike Bach. 'Coupled Soil–Leaf-Canopy and Atmosphere Radiative Transfer Modeling to Simulate Hyperspectral Multi-Angular Surface Reflectance and TOA Radiance Data'. *Remote Sensing of Environment* 109, no. 2 (2007): 166–82. https://doi.org/10.1016/j.rse.2006.12.013.