Climate Modelling User Group

Deliverable 2.0c - Interim Progress Report for WP 5.3

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

Centres providing input: Météo-France

Revision nr.	**Date**	**Status**
1.0	24 Oct. 2024	First version by JC Calvet and O Rojas-Munoz

CMUG CCI+ Deliverable 5.3.3

Interim Progress Report

Table of Contents

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

1. Purpose and scope of this report

This document is an interim technical report on a Cross-ECV climate science study dedicated to the assessment of the impact of integrating CCI land cover (LC) data in the Interactions between Soil, Biosphere, Atmosphere (ISBA) land surface model of Météo-France. Its purpose is to assess the impact on simulated soil moisture (SM) and land surface temperature (LST) of assimilating the SNOW CCI products using a pre-existing LC information and updated CCI LC information in the SURFEX (Surface externalisée) modelling platform of Météo-France (Masson et al. 2013, Le Moigne and Minvielle 2020) that includes the ISBA model. In SURFEX, the model parameters are spatialised using the ECOCLIMAP tool (Masson et al. 2003). This tool is used to convert land cover classes into functional vegetation types and to calculate the fraction covered by these types according to the spatial resolution used by the model. In addition to this information on vegetation, digital maps describing relief and soil properties such as sand and clay fractions are available in SURFEX. LC information in land surface models is often based on quite old EO observations and classifications. Quantifying the added value of regularly updated LC is a key question. CNRM has recently developed a new version of the land cover algorithm in SURFEX, called ECOCLIMAP-SG. Compared to the old ECOCLIMAP, ECOCLIMAP-SG is able to ingest CCI land cover maps at a spatial resolution of 300m. Comparing simulations using the new and the old ECOCLIMAP versions will allow assessment of the impact of CCI LC on the simulations of the CCI snow water equivalent (SWE) product. It will also allow assessing the impact on the assimilation of SWE using the LDAS-Monde tool, a data assimilation system operating sequentially, that was set up on a global scale (Albergel et al. 2017). This tool is based on a version of the ISBA model capable of simulating vegetation biomass and leaf area index (LAI). Assimilation improves the simulation of these quantities by using satellite products, as soon as an observation is available. The LDAS-Monde tool uses the sequential approach to assimilate LAI and surface soil moisture observations together. The assimilation is based on a Kalman filter. LDAS-Monde was upgraded to assimilate SWE.

This evaluation contributes to examine the following questions:

- How do LC uncertainties propagate to the water and energy budgets?
- Can Earth observation (EO) data improve land reanalyses?
- How does the assimilation of snow products improve the quality of land reanalyses?

2. Approach for assessing the impact of CCI LC data in ISBA

In addition to ISBA "open-loop" simulations, the LDAS-Monde land data assimilation system within the SURFEX modelling platform is used. The work is focussed over Eurasia at a spatial resolution of 0.25 x 0.25° from 2010 to 2022. The experimental and validation protocol is presented in Table 1, which includes the CCI product being assessed (LC, snow), and those used as a benchmark (LST, SM).

Table 1: Main features of CMUG WP5.3 on assessing the impact of integrating CCI LC land cover data in the ISBA land surface model.

CMUG WP 5.3: Assessment of the impact of CCI LC, Eurasia, 2010-2022		Status as of October 2024	Experiment type	CCI ECVs	Version of CCI ECVs
1	Open-loop with pre-existing LC	Done	Reanalysis		
2a	Open-loop with CCI LC	Done	Reanalysis	LC	LC v1.6.1 2008-2012
2b	Open-loop with CCI LC	Ongoing	Reanalysis	LC	LC v2.0.7 1992-2015
3	SWE assimilation with pre-existing LC	Ongoing	Reanalysis	Snow	SWE L3c v3.1
4	SWE assimilation with CCI LC	Ongoing	Reanalysis	Snow, LC	LC v2.0.7 1992-2015 SWE L3c v3.1
5	Comparison of simulated LST	Ongoing	Benchmarking	LST	V4 AQUA_MODIS_L3C_0.05, TERRA_MODIS_L3C_0.05
6	Comparison of simulated SM	Ongoing	Benchmarking	SM	SM COMBINED v8.1

3. First CMUG WP5.3 Results

3.1 CCI LC vs. pre-existing geographical information in SURFEX

Figure 1 presents three maps of the dominant land cover type over Eurasia at a spatial resolution of 0.25° x 0.25°, derived from ECOCLIMAP-II (Faroux et al. 2013), and from ECOCLIMAP-SG (Calvet and Champeaux 2020) with either versions v1.6.1 or v2.0.7 of CCI LC.
Major differences are observed between ECOCLIMAP-II and ECOCLIMAP-SG, with less bare soil, more forests, and more crops in ECOCLIMAP-SG.

More subtle differences can be observed between ECOCLIMAP-SG versions using v1.6.1 or v2.0.7 of CCI LC. For example, the more recent CCI LC map presents less grasslands at high latitudes.

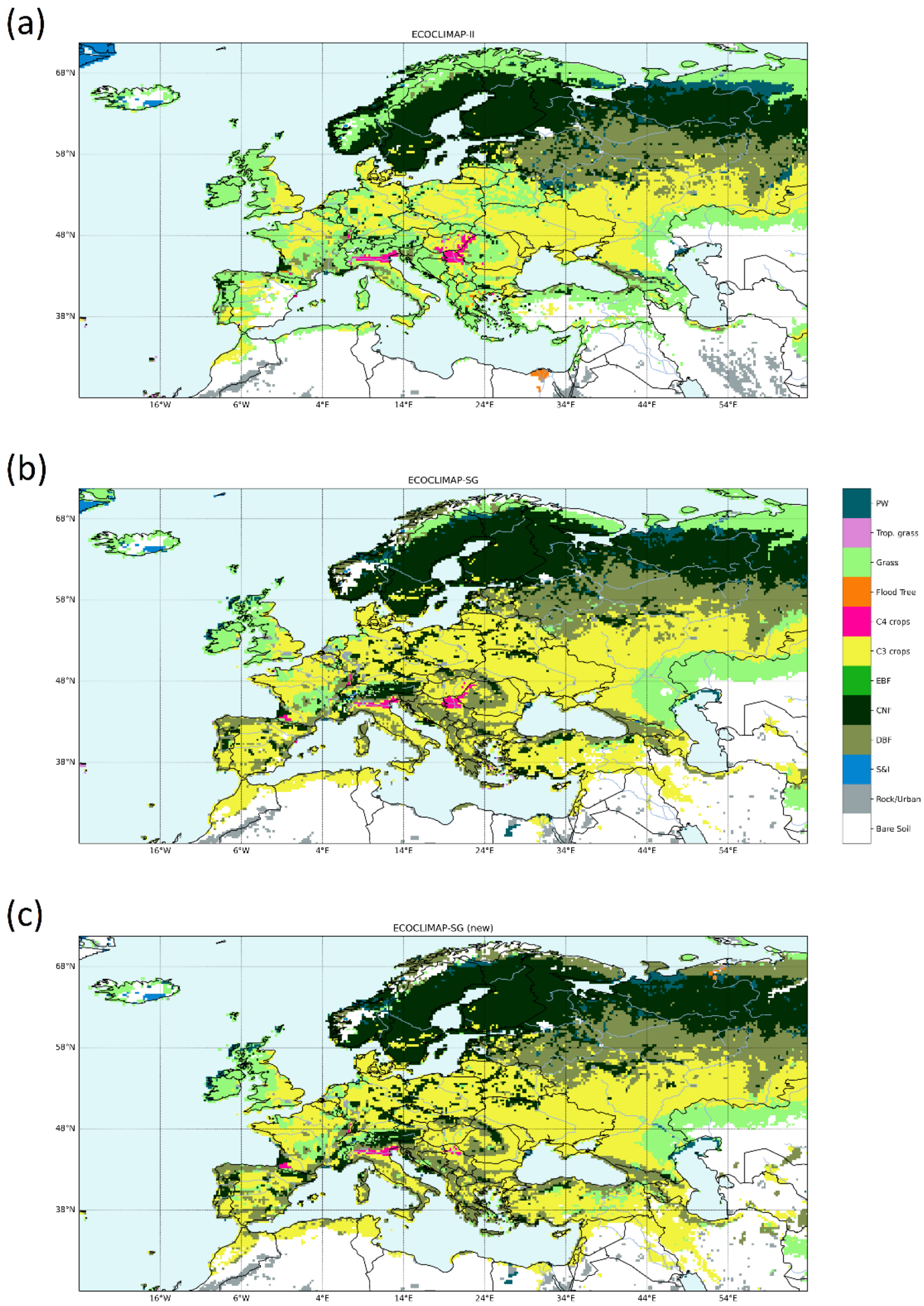

Figure 1*: Dominant land cover type over Eurasia at a spatial resolution of 0.25° x 0.25° as derived from (a) ECOCLIMAP-II (Faroux et al. 2013), (b) ECOCLIMAP-SG (Calvet and Champeaux 2020) with LC v1.6.1 2008-2012, (c) ECOCLIMAP-SG with LC v2.0.7 1992-2015. The 12 dominants land cover types are indicated in the colour bar from top to bottom: peat and wetlands, tropical grasslands, temperate grasslands, flooded trees/irrigation, C4 crops (e.g. maize), C3 crops (e.g. wheat), broadleaf evergreen trees, coniferous trees, deciduous broadleaf trees, permanent snow and ice, rocks/urban.*

3.2 Open-loop simulations

Open-loop simulation results are given for feature 1 in Table 1, i.e. using ECOCLIMAP-II.

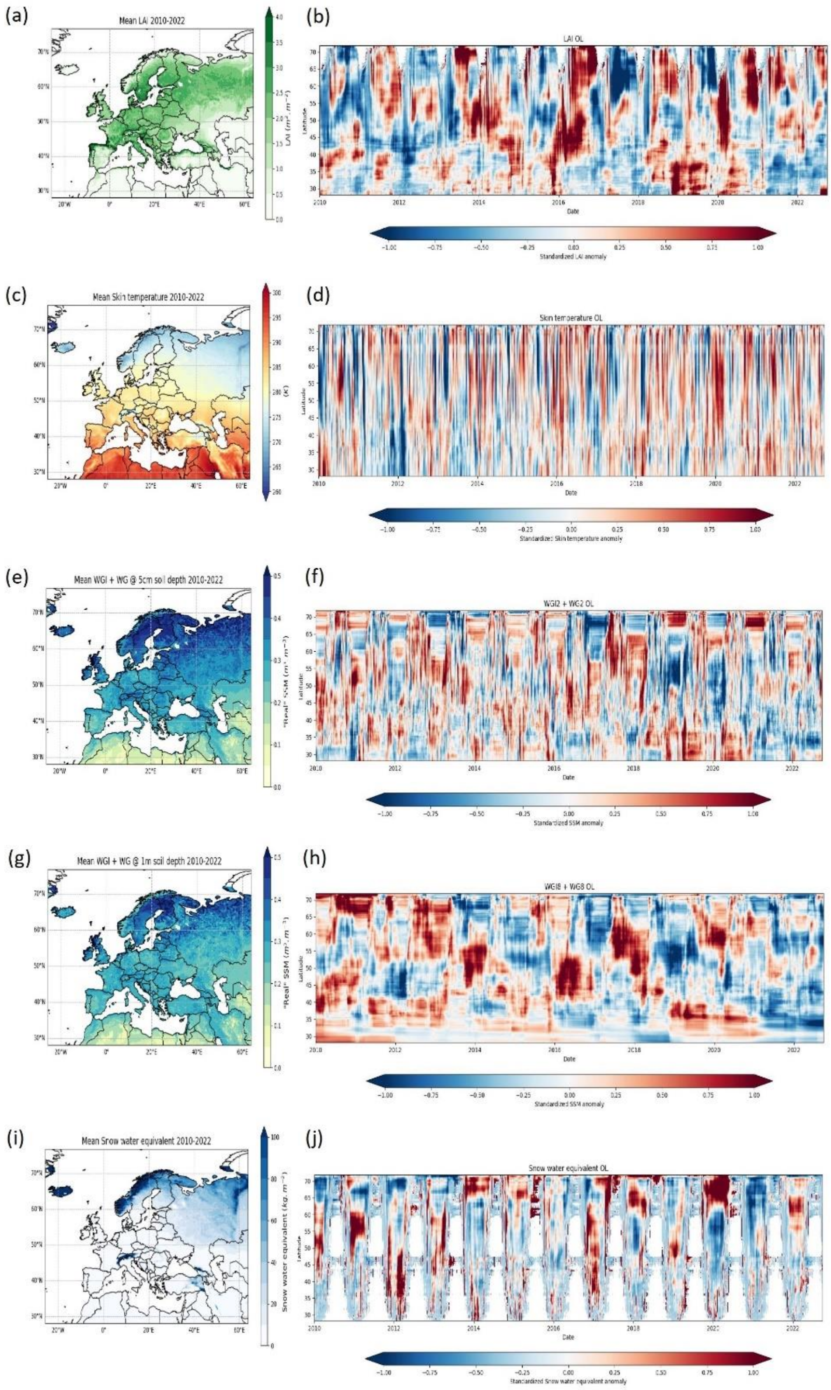

***Figure 2**: ISBA simulations over Eurasia forced by ERA5 atmospheric variables from 2010 to 2022 at a spatial resolution of 0.25° x 0.25°. Mean values (a,c,e,g,i) and Hovmoller plot (b,d,f,h,j) of scaled anomalies of (a,b) LAI, (c,d) LST, (e,f) surface soil moisture, (g,h) deep soil moisture (0.8-1.0m), (i,j) SWE.*

3.3 Impact of new land cover on simulated leaf area index

Updating ECOCLIMAP with LC CCI has a major impact on the simulated LAI, as shown by Figure 3. Mediterranean regions (urban areas) present larger (smaller) LAI values with LC CCI, in relation to less bare soil (larger cities).

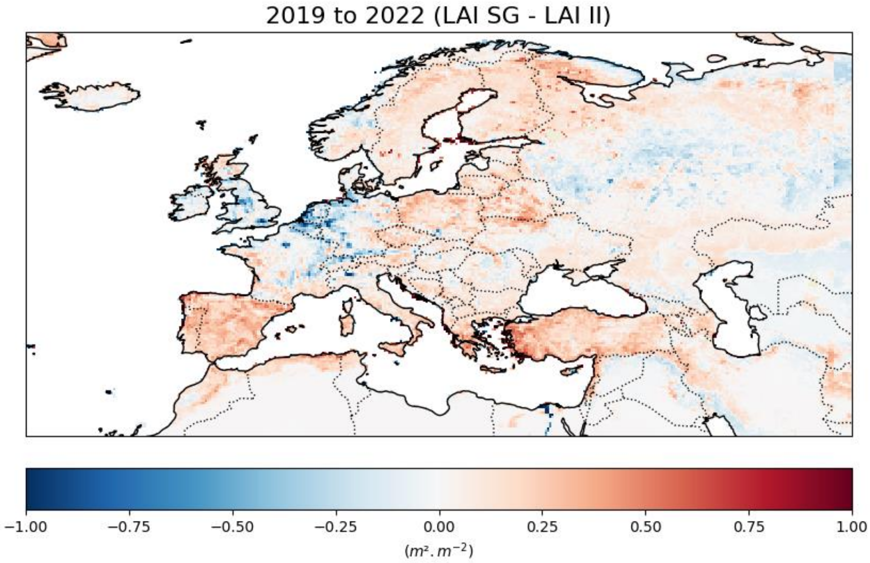

***Figure 3**: Mean LAI differences between feature 2a and 1 (Table 1) from 2019 to 2022.*

3.4 Snow CCI SWE product vs. open-loop simulations

Figure 4 presents a comparison of time series of mean SWE values over Eurasia between CCI Snow and ISBA open-loop simulations with and without CCI LC. There is a good agreement between the observations and the ISBA simulations. However, the model presents larger peak SWE values and the difference between the annual peak SWE values exceeds 75 mm in 2014 and 2020. Figure 2 shows that 2014 and 2020 correspond to warm winters with positive anomalies of LAI, LST, positive anomalies of SWE at high latitudes (65-70°N) and negative anomalies of SWE at mid-latitudes (45-60°N). The large bias observed in these conditions needs to be investigated.

Figure 5 presents the geographical distribution of mean SWE values and CCI minus model differences. In spite of simulated SWE annual peaks larger than observed, the simulated mean SWE values are smaller than the CCI SWE in some regions such as Western Europe, Sweden, Finland.

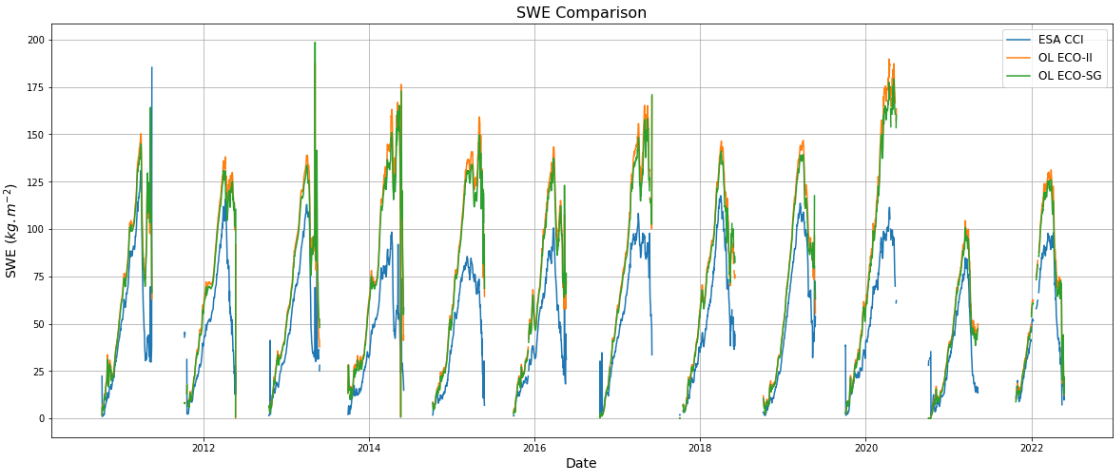

***Figure 4**: Mean SWE value over Eurasia from CCI Snow, ISBA open-loop simulations feature 2a and 1 (Table 1) from 2019 to 2022.*

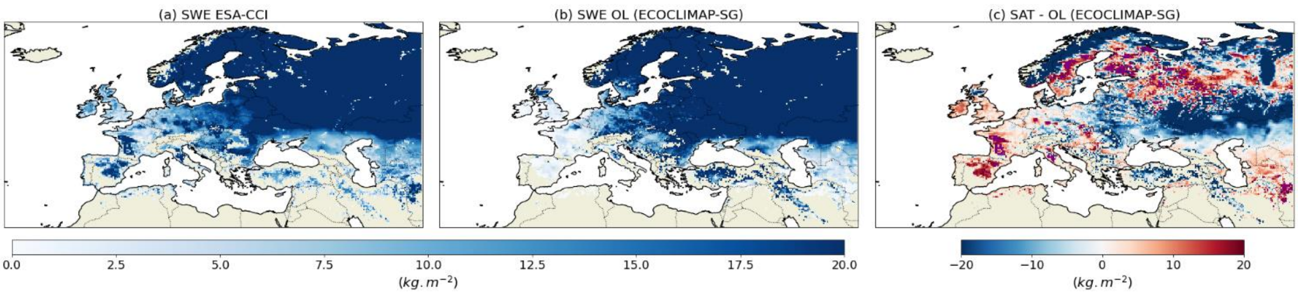

***Figure 5**: Map of mean SWE value over Eurasia from (a) CCI Snow, (b) ISBA open-loop simulations feature 2a (Table 1), and (c) the difference between CCI Snow and ISBA open-loop simulations feature 2a (Table 1).*

4. Conclusions

Land surface variables were simulated by the ISBA land surface model over Eurasia at a spatial resolution of 0.25°x0.25° from 2010 to 2022. Simulations were performed with and without CCI LC. The simulated SWE was compared with the CCI SWE observations. The next step will be to produce simulations including the assimilation of CCI SWE observations with and without CCI LC and to compare the simulations with other CCI ECVs such as LST and SM.

5. References

Albergel, C., Zheng, Y., Bonan, B., Dutra, E., Rodríguez-Fernández, N., Munier, S., Draper, C., de Rosnay, P., Muñoz-Sabater, J., Balsamo, G., Fairbairn, D., Meurey, C., and Calvet, J.-C.: Data assimilation for continuous global assessment of severe conditions over terrestrial surfaces, Hydrol. Earth Syst. Sci., 24, 4291–4316, https://doi.org/10.5194/hess-24-4291-2020, 2020.

Calvet, J.-C. and Champeaux J.-L.: L'apport de la télédétection spatiale à la modélisation des surfaces continentales, La Météorologie, 108, 52–58, https://doi.org/10.37053/lameteorologie-2020-0016, 2020.

Faroux, S., Kaptué Tchuenté, A. T., Roujean, J.-L., Masson, V., Martin, E., and Le Moigne, P.: ECOCLIMAP-II/Europe: a twofold database of ecosystems and surface parameters at 1 km resolution based on satellite information for use in land surface, meteorological and climate models, Geosci. Model Dev., 6, 563–582, https://doi.org/10.5194/gmd-6-563-2013, 2013.

Le Moigne P., Minvielle M.: SURFEX : une plateforme pour simuler les flux des surfaces océaniques et continentales, La Météorologie, 108, 82-87, https://doi.org/10.37053/lameteorologie-2020-0020, 2020.

Masson V., Champeaux J.-L., Chauvin F., Meriguet C., Lacaze R.: A global database of land surface parameters at 1-km resolution in meteorological and climate models. J. Climate, 16, 1261-1282, https://doi.org/10.1175/1520-0442-16.9.1261, 2003.

Masson V., Le Moigne P., Martin E., Faroux S., Alias A., Alkama R., Belamari S., Barbu A., Boone A., Bouyssel F., Brousseau P., Brun E., Calvet J.-C., Carrer D., Decharme B., Delire C., Donier S., Essaouini K., Gibelin A.-L., Giordani H., Habets F., Jidane M., Kerdraon G., Kourzeneva E., Lafaysse M., Lafont S., Lebeaupin-Brossier C., Lemonsu A., Mahfouf J.-F., Marguinaud P., Mokhtari M., Morin S., Pigeon G., Salgado R., Seity Y., Taillefer F., Tanguy G., Tulet P., Vincendon B., Vionnet V., Voldoire A.: The SURFEXv7.2 land and ocean surface platform for coupled or offline simulation of earth surface variables and fluxes. Geosci. Model Dev., 6, 929-960, https://doi.org/10.5194/gmd-6-929-2013, 2013.