Climate Modelling User Group [CMUG]

Deliverable D2.0bv1 (5.2.1)

Short report on testing of preliminary CCI Vegetation LAI dataset

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Contents

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1. Aim of the deliverable

The WP5.2 study aims to quantify the relationship between changes in plant phenology and land-atmosphere exchanges. This study, then, uses the new Leaf Area Index (LAI) data prepared by the Vegetation Climate Change Initiative (CCI) team to estimate the vegetative phases.
The present deliverable provides a short report on the exchange of information and feedback between the WP5.2 CMUG team (i.e. users) and the Vegetation CCI team (i.e. developers) as a result of the task 5.2.1 activities. In particular, the principal outcomes of each meeting between the two groups and the preliminary results are described in Section 2 and Section 3, respectively.

2. CMUG – CCI communication activities

The first task of WP5.2 requires collaboration and communication between LAI data developers (i.e. Vegetation CCI team) and users (i.e. WP5.2 CMUG team) to provide feedback on the newly produced LAI data. This goal has been reached through online meetings between the two involved groups (Table 1).
After a kick-off meeting on the planned activities and timelines, the first release of the LAI data (available at https://catalogue.ceda.ac.uk/uuid/34e4bfe402c048c783e64eac0f0bca37 since the 18th of December 2023) from the Vegetation CCI group leads to a more active discussion between users and developers.
The first dialogue between the two communities concentrates on variable differences and usage of the novel product. Once discussed these features, the WP5.2 CMUG team, in collaboration with WP5.3, started to use the data and supply a list of needs and feedback on the prepared data.
The first point discussed between the CMUG teams and the Vegetation CCI team concerns the need to bridge the difference in horizontal and temporal resolution between satellite-derived data and model outputs. To address this issue, the WP5.2 CMUG team in collaboration with the Vegetation CCI group developed a preliminary tool able to aggregate the LAI data at various spatial resolutions (further details in Section 3).
Secondly, the prepared data assumes that the leaves are randomly distributed (i.e. effective LAI). On the contrary, models account for non-randomly distributed foliage (i.e. true LAI). The difference between those two LAI definitions resides in the canopy clumping index. For this reason, the Vegetation CCI will provide this parameter in future releases of the product to overcome this discrepancy and respond to this request from the users.
The last meeting between the WP5.2 CMUG team and the Vegetation CCI team focused on discussing the preliminary results obtained using the developed aggregation tool in order to take advantage of all information provided in the newly produced dataset.

Meeting date	Main Outcomes
13 September 2023	Kick-off of the WP5.2 activities. CMUG and Vegetation CCI groups present preliminary ideas, plans and timelines for the production and usage of the new ECVs (i.e. LAI).
11 January 2024	Preliminary discussion on the first release of LAI data provided by the Vegetation CCI team to supply guidance on data usage to the CMUG team.
22 April 2024	Meeting in collaboration with WP5.3. The two CMUG teams present and discuss the principal users' requirements and feedback: 1) data aggregation in time and space and 2) clumping index to compute true LAI values.
25 June 2024	The WP5.2 CMUG team presents and discusses with the Vegetation CCI team the preliminary results obtained using a preliminary tool to compute LAI spatial aggregation (Section 3).

Table 1. Main outcomes of the CMUG - Vegetation CCI online meetings.

3. Data usage and tool development

The users could work with the first release of the LAI dataset (available at https://catalogue.ceda.ac.uk/uuid/34e4bfe402c048c783e64eac0f0bca37 since the 18th of December 2023). This dataset covers a north-south transect from Scandinavia to South Africa (Figure 1). Based on the initial usage of this dataset, the discussion between developers and users started.

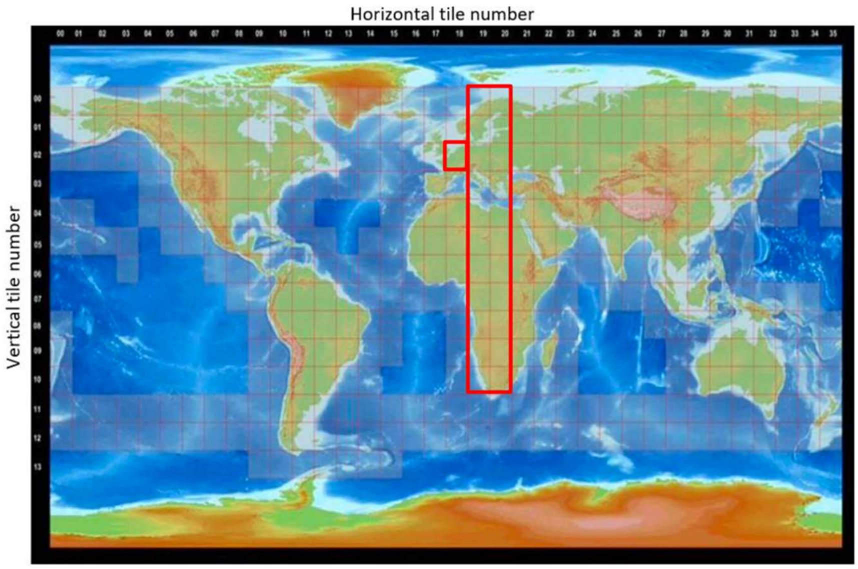

Figure 1. The red outlined area indicated the tiles that are provided in the first LAI data release. The tiling is based on Wolters et al. (2023). Figure taken from Swinnen et al. (2023).

The discussion between the CMUG and Vegetation CCI teams lead to the shared development of a tool for spatial data aggregation. The users need to bridge the gap between the satellite data resolution (nominal resolution of 1km) and the standard model resolutions, which span from 10

to 100 km. The developed aggregation method accounts for data quality and error provided within the LAI dataset.
In particular, the tool works through three main steps:

1. it applies a filter to the original LAI data to select quality data;
2. it aggregates the data based on the relative error of each point in the aggregation domain;
3. it averages and propagates the error in the aggregation domain.

The first step makes use of the "invcode" flag provided within the dataset. This flag contains diagnostics about the inversion code and data quality levels (Swinnen et al., 2023). Consequently, various levels of data filtering can be retained based on data usage and details needed. For this reason, three levels of filtering are available in the created tool (Figure 2):

1. the first filter removes data flagged with code 256;
2. the second filter takes out data flagged with code from 256 to 510;
3. the strictest filter applies the second filter and adds flag 512 among the removed flags.

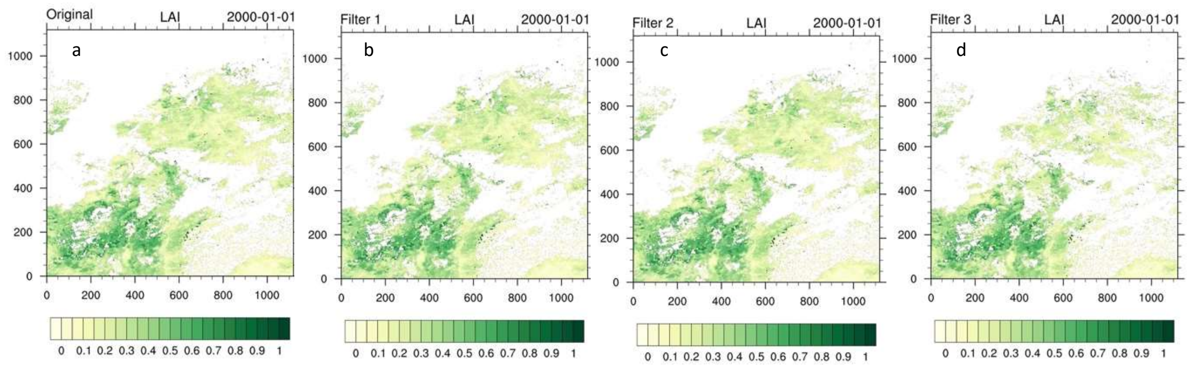

Figure 2. Filtering. The original data excludes 587335 points in the domain (a); filters 1 (b) and 2 (c) exclude 588798 points; the strictest filter (i.e. filter 3) removes 638732 points (d). The selected tile in this example is the X18Y02 located in the centre of Europe (Figure 1).

At this stage, the filtered data are aggregated at a coarser resolution based on the users' needs. The aggregation uses the relative error of each value in the aggregation domain to perform a weighted average (Figure 3). This is done using:

$$LAI_{agg} = \frac{\sum_i \left(LAI_i / LAI_{re,i}^2 \right)}{\sum_i \left(1 / LAI_{re,i}^2 \right)} \qquad (1)$$

where i is the index for each grid point in the aggregation domain and $LAI_{re,i}$ is relative error of the i-th point in the aggregation domain, computed as:

$$LAI_{re,i} = \frac{LAI_{err,i}}{LAI_i} \qquad (2)$$

Where $LAI_{err,i}$ is the LAI error of the i-th point in the aggregation domain.

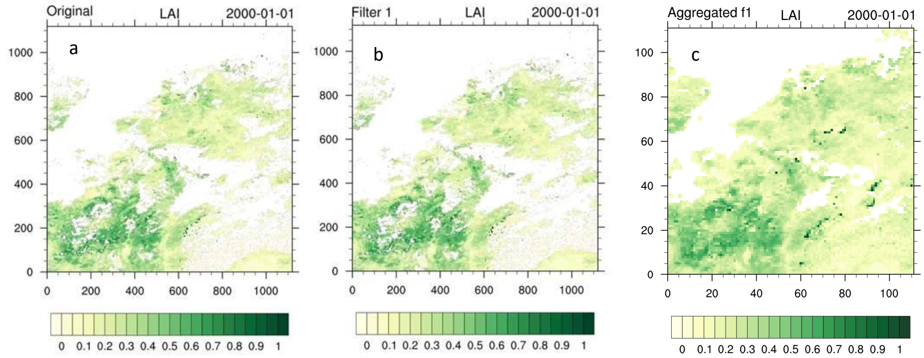

Figure 3. Aggregation. The original data (a) are filtered with the first filter (b) and aggregated (c) from the original ~1km to ~10km resolution using equation (1).

Another option consists of averaging the data in the aggregation domain and propagating the error associated with each point in the aggregation domain. Different from the previous aggregation method, this technique provides uncertainty ranges to the final LAI values (Figure 4).

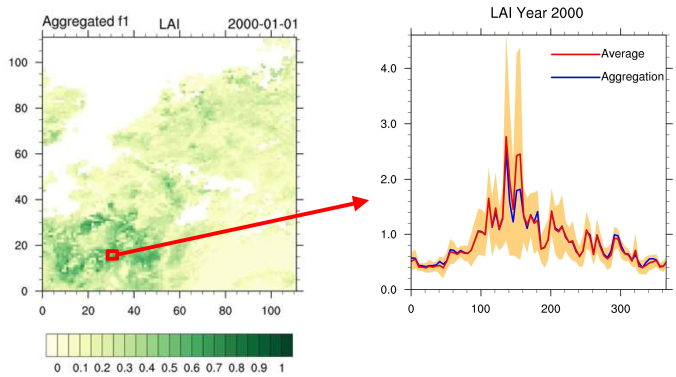

Figure 4. LAI timeseries. Comparison of aggregated (blue line) and averaged (red line plus orange shade for uncertainty range) LAI timeseries in a specific ~10km region.

However, the aggregation method reduces the influence of outliers in the final LAI values. This effect is mainly visible on day 150 of 2000, where the major difference between the two techniques occurs (Figure 4). On that day, the original 1 km points have LAI values ranging between 1.1 and 6.8 m^2/m^2 associated with errors up to 3.6 m^2/m^2. The combination of high variability of LAI values and high uncertainty can partially explain the difference between the two aggregation methodologies. Nevertheless, the two approaches provide comparable changes in LAI values.

4. Summary

Task 5.2.1 provided the opportunity to establish a regular exchange of information between developers and users, which enhanced the interactions between the CMUG and the CCI communities. Moreover, these discussions brought the development of a tool that will be employed within the CMUG WP5.2 future activities and support the tailoring of the data produced by the Vegetation CCI team.
This collaboration will remain active during the second phase of CMUG WP5.2 activities to provide further users' requests and exchange ideas and suggestions on future data releases and analysis results.

5. References

Swinnen, E., Vanhoof, K., Sanchez, J., Blessing, S., Van der Tol, C. (2023), CCI+ Vegetation Parameters Product User Guide CRDP-1, 53 p., https://climate.esa.int/media/documents/VP-CCI_D4.2_PUG_V1.2.pdf

Wolters, E. C. Toté, W. Dierckx, M. Paepen and E. Swinnen (2023), PROBA-V Collection 2 Products User Manual v1.0, 78 p. https://proba-v.vgt.vito.be/sites/probavvgt/files/downloads/PROBA-V_C2_Products_User_Manual.pdf

6. Glossary

Terms	
Data assimilation	Observations directly influence the model initial state taking into account their error characteristics during every cycle of a model. This is used for reanalysis, NWP, which includes seasonal and decadal forecasting.
Model validation	Observations are compared with equivalent model fields to assess the accuracy of the model. This can be on short time scales for process studies or long time scales for climate trends.
Climate monitoring	This describes the use of a satellite only dataset to monitor a particular atmospheric or surface variable over a period > 15yrs to investigate whether there is a trend due to climate change.
Initialisation	To initialise prognostic quantities of the model with reasonable values at the beginning of the simulation but do not continuously update.
Prescribe boundary conditions	Prescribe boundary conditions for a model run for variables that are not prognostic (e.g. land cover, ice caps etc).
Accuracy	Accuracy is the measure of the non-random, systematic error, or bias, that defines the offset between the measured value and the true value that constitutes the SI absolute standard.
Stability	Stability is a term often invoked with respect to long-term records when no absolute standard is available to quantitatively establish the systematic error – the bias defining the time-dependent (or instrument-dependent) difference between the observed quantity and the true value.

Precision	Precision is the measure of reproducibility or repeatability of the measurement without reference to an international standard so that precision is a measure of the random and not the systematic error. Suitable averaging of the random error can improve the precision of the measurement but does not establish the systematic error of the observation.
Effective Leaf Area Index (LAI_{eff})	The effective LAI (LAI_{eff}) is defined as the LAI value that would produce the same indirect ground measurement as that observed, assuming a simple random foliage distribution.
canopy clumping index	canopy clumping index describes the non-randomness of the leaf foliage distribution.
Acronyms	
(A)ATSR	(Advanced) Along Track Scanning Radiometer on ERS -1&2 and ENVISAT
AVHRR	Advanced Very High Resolution Radiometer
BADC	British Atmospheric Data Centre
CALIPSO	Cloud-Aerosol Lidar and Infrared Pathfinder Satellite
CCI	Climate Change Initiative
CCMVAL	Chemistry-Climate Model Validation Activity
CDR	Climate Data Record
CMC	Climate Modelling Community
CMIP5	Climate Model Intercomparison Project-5
CMUG	Climate Modelling Users Group
COSP	CMIP5 Observation Simulator Package
CSAB	Climate Scientific Advisory Board
DAAC	Distributed Active Archive Centres
ECV	Essential Climate Variable
EGU	European Geophysical Union
ENSO	El Nino- Southern Oscillation
ERA	ECMWF Reanalysis
ERBS	Earth Radiation Budget Satellite
ERRMERG	Error of merged dataset
FAPAR	Fraction of Absorbed Photosynthetically Active Radiation
FCDR	Fundamental Climate Data Record
FOAM	The Fast Ocean Atmosphere Model
GCOS	Global Climate Observing System
GPS	Global Positioning System
GSICS	GCOS Satellite InterCalibration System
HIRS	High resolution Infrared Radiation Sounder
IGOS	Integrated Global Observing Strategy
IPCC	International Panel for Climate Change
ISCCP	International Satellite Cloud Climatology Project
LAI	Leaf Area Index

MACC	Monitoring Atmospheric Composition and Climate
METAFOR	Common Metadata for Climate Modelling Digital Repositories
NAO	North Atlantic Oscillation
NWP	Numerical Weather Prediction
OSTIA	Operational Sea Surface Temperature and Sea Ice Analysis
PCMDI	Program for Climate Model Diagnosis and Intercomparison
PDO	Pacific Decadal Oscillation
SAGE	Stratospheric Aerosol and Gas Experiment
SSAOB	Single sensor accuracy for each observation
SSEOB	Single sensor error for each observation
SSM/I	Special Sensor Microwave Imager
SST	Sea Surface Temperature
TCDR	Thematic Climate Data Record
UMARF	Unified Meteorological Archive and Retrieval Facility