LAI\_TS\_Val: LAI time-series validation datasets in the 1-km pixel grid at global scale from 2001 to 2011

Baodong Xu, Jing Li, Qinhuo Liu

(xubd@radi.ac.cn; lijing01@radi.ac.cn)

State Key Laboratory of Remote Sensing Science, Aerospace Information Research Institute, Chinese academy of sciences

* **Introduction**

Leaf area index (LAI), which is defined as one half of the total green leaf area per unit ground surface area, is a critical structural variable for quantifying the exchange processes of energy and matter between the land surface and atmosphere, it is thus identified as a key parameter in most terrestrial ecosystem models. To acquire long-term LAI records at the global scale, several remote sensing LAI products have been generated from various satellite sensors. Assessing the uncertainties associated with these LAI products through comparisons with independent ground-truth measurements is pivotal for an effective application of products. Many regional field campaigns (e.g. VALERI, BigFoot, SAFARI 2000, etc.) have collected and provided invaluable ground LAI measurements covering a wide range of biome types and spatial variabilities. However, most previous studies were limited to evaluate the temporal performance of the LAI products due to limited resources for collecting time-series of ground LAI via recursive field campaigns. This restriction is critical because assessing the temporal performance of these products enables us to better understand the structure of the uncertainties and their evolution across seasonal or annual contexts.

To improve the temporal assessment capability, many sites from global networks have collected and provided continuous ground LAI measurements using onboard instruments or recursive data collection. These site-based LAI measurements have been obtained about 30 years (1990-now), which is promising to evaluate the performance of long-term global products. However, the spatial scale mismatch restricts the utilization of LAI measurements from these networks as the LAI is conventionally measured within an area of tens of meters around a site. The scale issue usually introduces undesired errors in the validation of remote sensing products because the spatially heterogeneous land surface results in incomparability between observations from sites and satellites. Therefore, it is necessary to generate the LAI validation dataset in the product pixel grid using the site-based LAI measurements for the comprehensive evaluation of product time series.

* **Generating LAI time-series validation dataset in the 1-km pixel grid**

This LAI validation datasets were generated from site-based LAI measurements of FLUXET and Chinese Ecosystem Research Network (CERN) (Fig.1), using the proposed GUGM (Grading and Upscaling of Ground Measurements) method to resolve the scale-mismatch issue between site and sensor observations and maximize the utility of time-series of site-based LAI measurements. This GUGM approach first ingests both high-resolution images and site-based LAI measurements to capture the spatiotemporal variability in the product pixel grid. Then, a strategy was employed to grade the spatial representativeness of LAI measurements in the product pixel grid. For those LAI measurements which cannot be directly used in the validation of products, a strategy was adopted to calculate the spatial upscaling coefficient based on site-based LAI measurements and aggregated high-resolution reference maps to derive reliable LAI time-series validation datasets. The GUGM method has been applied to the site-based LAI measurements to generate global time-series LAI validation datasets from 2001 to 2011 in the 1 km pixel grid. For more details of GUGM method, please refer to Xu et al. (2016, 2018).

**Table 1.** Characteristics of global sites from 2001 to 2011 used in this study. “N obs.” indicates the number of ground LAI measurements at each site. The average (*µ*) and standard deviation (*σ*) of the LAI measurements are reported in the last column.

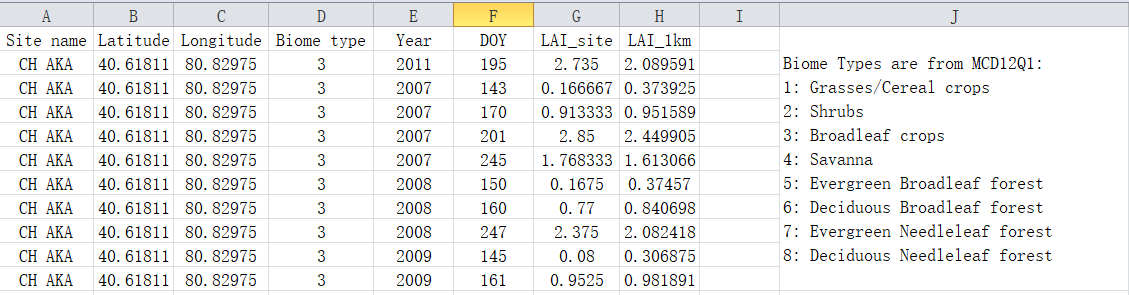
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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| N | Site Name | Country | Lat.  [deg] | Long.  [deg] | Observed vegetation type | Year | N obs. | Effective/  True LAI | LAI (*µ*±*σ*) |
| 1 | US ARM | USA | 36.61 | -97.49 | Cropland | 2002-2006 | 5 | Effective | 1.90±0.65 |
| 2 | US SP | USA | 29.74 | -82.22 | Forest | 2001-2007 | 74 | True | 3.64±0.75 |
| 3 | US DK | USA | 35.97 | -79.09 | Grassland | 2001-2007 | 36 | Effective | 1.47±1.12 |
| 4 | US IB | USA | 41.86 | -88.22 | Cropland | 2005-2008 | 21 | Effective | 1.29±1.17 |
| 5 | US Ha | USA | 42.54 | -72.17 | Forest | 2005-2010 | 57 | Effective | 3.77±1.39 |
| 6 | US Ho | USA | 45.20 | -68.74 | Forest | 2006 | 7 | True | 5.20±0.52 |
| 7 | US Ne | USA | 41.17 | -96.48 | Cropland | 2001-2009 | 82 | True | 3.37±2.15 |
| 8 | US MMS | USA | 39.32 | -86.41 | Forest | 2001-2010 | 183 | Effective | 3.16±1.39 |
| 9 | US Ton | USA | 38.43 | -120.97 | Grassland | 2001-2006 | 51 | Effective | 0.61±0.39 |
| 10 | US UMB | USA | 45.56 | -84.71 | Forest | 2001-2007 | 87 | Effective | 2.81±0.87 |
| 11 | CA AB-GRL | Canada | 49.71 | -112.94 | Grassland | 2001-2006 | 80 | True | 0.45±0.31 |
| 12 | CA BC-DF00 | Canada | 49.87 | -125.29 | Forest | 2001-2005 | 26 | True | 2.73±1.02 |
| 13 | CA BC-DF88 | Canada | 49.53 | -124.90 | Forest | 2002-2005 | 31 | True | 5.75±1.35 |
| 14 | CA ON-ONW | Canada | 48.22 | -82.16 | Forest | 2003-2004 | 6 | True | 2.89±0.34 |
| 15 | CA SK-OA | Canada | 53.63 | -106.20 | Forest | 2002-2005 | 9 | True | 1.45±1.03 |
| 16 | CA SK-OJP | Canada | 53.92 | -104.69 | Forest | 2001-2005 | 7 | True | 1.91±0.07 |
| 17 | CA SK-SOBS | Canada | 53.99 | -105.12 | Forest | 2001-2004 | 6 | True | 3.03±0.32 |
| 18 | PH IRI | Philippines | 14.20 | 121.30 | Cropland | 2009-2010 | 62 | True | 3.51±1.63 |
| 19 | ID BKS | Indonesia | 0.86 | 117.04 | Forest | 2001-2002 | 18 | True | 2.65±0.76 |
| 20 | TH MKL | Thailand | 14.58 | 98.84 | Forest | 2003-2004 | 15 | True | 1.88±0.37 |
| 21 | TH SKR | Thailand | 14.49 | 101.92 | Forest | 2001-2003 | 14 | True | 3.17±0.70 |
| 22 | CH AKA | China | 40.62 | 80.83 | Cropland | 2007-2011 | 25 | True | 1.85±1.35 |
| 23 | CH LCA | China | 37.89 | 114.69 | Cropland | 2004-2011 | 64 | True | 2.68±1.87 |
| 24 | CH SYA | China | 41.52 | 123.37 | Cropland | 2005-2011 | 29 | True | 2.35±1.93 |
| 25 | CH YCA | China | 36.83 | 116.57 | Cropland | 2004-2011 | 94 | True | 2.65±1.97 |
| 26 | CH FQA | China | 35.02 | 114.55 | Cropland | 2004-2011 | 78 | True | 2.44±1.70 |
| 27 | CH CSA | China | 31.55 | 120.70 | Cropland | 2004-2011 | 76 | True | 4.44±2.37 |
| 28 | CH YGA | China | 31.27 | 105.46 | Cropland | 2005-2011 | 45 | True | 2.29±1.80 |
| 29 | CH TYA | China | 28.93 | 111.44 | Cropland | 2006-2011 | 57 | True | 2.35±1.63 |
| 30 | CH CWA | China | 35.24 | 107.68 | Cropland | 2004-2011 | 30 | True | 2.28±2.04 |
| 31 | CH QYA | China | 26.74 | 115.07 | Cropland | 2004-2011 | 73 | True | 3.33±2.00 |
| 32 | CH CBF | China | 42.40 | 128.10 | Forest | 2005-2010 | 14 | Effective | 4.69±2.34 |
| 33 | CH BJF | China | 39.96 | 115.43 | Forest | 2002-2010 | 44 | Effective | 1.85±0.58 |
| 34 | CH HTF | China | 26.85 | 109.61 | Forest | 2004-2011 | 73 | Effective | 2.55±1.33 |
| 35 | CH LSA | China | 29.68 | 91.34 | Cropland | 2003-2011 | 34 | True | 2.76±2.58 |
| 36 | CH YTA | China | 28.21 | 116.92 | Cropland | 2004-2011 | 35 | True | 2.71±1.85 |
| 37 | CH ASA | China | 36.86 | 109.32 | Cropland | 2004-2011 | 28 | True | 2.25±1.83 |
| 38 | CH HJA | China | 24.74 | 108.32 | Cropland | 2007-2011 | 17 | True | 1.51±1.15 |

* **Overview of LAI time-series validation dataset**

The datasets include 28 sites (Fig. 1) which are mainly located in North America and Asia, providing 924 validation data from 2001 to 2011. Among these sites, 16 sites with 508 (55.0%) validation data were obtained for forest, while 11 sites with 341 (36.9%) validation data and one site with 75 (8.1%) were obtained for crops and grasses, respectively (Fig. 2). This datasets were saved in two formats: \*.xls and \*.kmz and each format was zipped for 63 KB and 31 KB, respectively.

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**Fig. 1**. (a) The differences in the LAI range between the site-based LAI measurements and the spatially upscaled LAI validation dataset in the 1-km pixel gird derived using the GUGM method for each site and a comparison of the LAI changes between the site-based LAI measurements and the LAI validation dataset on a temporal trajectory at the (b) CH YCA site.



**Fig. 2.** The example of LAI validation dataset in the 1-km pixel grid.

* **References**

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