List of Recommendations (January 2014)

Recommendations/Actions for CEOS WGCV LPV	
1.	CEOS LPV should compile a global database of in-situ LAI estimates, which should be hosted by CEOS Cal/Val Portal. This should include, where possible, raw measurement files for indirect measurements.
2.	CEOS LPV in collaboration with CEOS Cal/Val portal should archive existing reference LAI maps suitable for comparison with global products within a central database using standard metadata. Regional experts should review the maps to assess the accuracy and also temporal extent, over which they are relevant, and this information should be included in the reference map metadata.
3.	CEOS LPV should compile a list of in-situ sites critical for temporal revisit, with inputs by the LPV community. The basis for this is BELMANIP2[1] guided by analysis of co-located satellite based phenological indices. This list would form a priority for site revisit.
4.	CEOS LPV should provide a spatially indexed (e.g. by biome, land cover and BELMANIP2 site) database of performance statistics. The completeness of these statistics should be reported by product to respond to the GCOS Implementation Plan Action Item T29.
Recommendations to LAI Product Producers	
5.	Producers of global products should participate in the production of LAI reference maps to enhance the current sampling across different land cover conditions. These should be provided to the LPV database for the community to use (see 3).
6.	Producers should provide updates of LAI product metadata to CEOS WGCV LPV with each revision (see 2).
7.	Producers should provide a full and traceable description of the algorithms for generating LAI products complete with all ancillary data dependencies. Ideally the code should be made accessible along with sample standard input data for validation studies over sites used for CEOS Stage 1 validation.
8.	Producers should generate standard performance statistics from new products (e.g. using OLIVE). These statistics should be provided to CEOS for construction of the database within the Cal/Val Portal.
Recommendations to Scientific Research Community	
9.	Scientists who generate or have existing LAI estimates suitable as reference LAI maps should provide these to CEOS WGCV LPV as they become available to help build a validation database. All data should be fully acknowledged and its use credited whenever papers are published.

[1] BELMANIP2 is a CEOS WGCV Global Stratification for LAI Validation. See (Baret et al. 2006) for V1. V2 is a revisit of V1 to make it more compatible with the needs of validation and inter-comparison of 1km products. The sites selected can be downloaded from the CalVal Portal/OLIVE website: http://calvalportal.ceos.org/web/olive/site-description. It will be updated as new sites become available

10.	Custodians of in-situ LAI measurement methods should provide CEOS with nominal and upper bound accuracy ranges for them. These ranges should be reviewed by independent experts.
11.	The scientific community involved in validation of satellite LAI estimates should develop an upscaling tool to model spatial prediction errors considering the spatial distribution of residuals.
12.	The temporal extent of the representativeness of current and future in-situ sites (e.g. BELMANIP2) should be documented.
13.	The scientific community should develop/test approaches (including those proposed in the CEOS WGCV LPV good practice guideline) for quantifying intra- and inter- annual temporal precision of LAI products.
14.	The scientific community should analyse the database of in-situ LAI measurements corresponding to temporal validation sites identified in 4 to identify those sites in sufficiently homogenous areas to produce initial reference maps through simple statistical upscaling.
15.	The scientific community should develop good practice guidelines for the use of reference maps generated from high accuracy remote sensing retrievals (e.g. from locally calibrated LIDAR or hyperspectral imagery) that have been regionally evaluated. These should be provided to CEOS WGCV LPV for hosting on the Cal/Val Portal.
Recommendations for LAI Product Validation Teams	
16.	Both overstory and understory LAI should be measured within in-situ reference datasets and if possible reported separately.
17.	In-situ measurements and processed results should be documented and archived with suitable metadata by the measurement team or within the CAL/Val portal.
18.	A quantitative assessment of the accuracy of in-situ LAI estimates should be included with reference data and should be used when propagated into uncertainty estimates for reference LAI maps.
19.	The methods used for selecting ESU locations for upscaling should be described.
20.	Replicate sampling should be performed for each stratified land cover within a reference LAI image.
21.	Randomization should be applied where possible when selecting samples within a land cover stratum for producing reference LAI maps.
22.	The prediction confidence interval of upscaled LAI estimates should be quantified using boot strap validation.
23.	To account for geolocation issues, validation should be performed using mapping units larger than nominal pixel size of the product.
24.	LAI product intercomparisons should be conducted at a monthly temporal aggregation interval for LPV in addition to any other temporal aggregation intervals desired by the validation team.

25.	If LAI products include temporal interpolation of products the comparison should be made with and without the interpolation if possible. The range of LAI over the reference site during the product interval should also be quantified.
26.	Whenever new reference sites are generated they should be introduced in BELMANIP2 regions in a manner that covers the dominant conditions of each region. Every effort should be made to maintain the balance of sites in terms of land cover proportions within BELMANIP2.
27.	For validation exercises the spatial and temporal distribution of residuals should be checked by the validation team to ensure a fair assessment of global products.
28.	The spatial trend in residuals between upscaled and ESU LAI estimates should be uniform and documented.
29.	Validation statistics should be spatially organized in a hierarchical structure starting globally and then partitioning to successively more detailed units such as biomes, continental biomes, land cover within continental biomes, and finally each validation core site.
30.	Validation studies should refer to the hierarchical validation levels (see 31) when reporting results. Ideally these should be provided to CEOS LPV to tabulate statistics as a function of hierarchical level.
31.	Where data permits, validation statistics should be derived seasonally for individual years. Where this is not possible average seasonal values maybe used for assessment of bias.
32.	Statistics related to linear comparisons of reference and product LAI should be reported using non-parametric analogues (see Table 6 of the Good Practice Guidelines).
33.	Non parametric accuracy statistics along with visualisations should be provided at each level of aggregation at which accuracy is assessed. Comparisons of accuracy across products or sites should be performed in an ordinal manner in addition to reporting standard error statistics to deal with variation in population sizes and reference data quality across space and time.
34.	The CEOS goals for LAI accuracy and stability (see Table 5 of Good Practice Guidelines) are cited as a combination of absolute and proportional errors. As such, residuals should be summarized in absolute and relative terms.
35.	The agreement of products to reference LAI should be reported as a function of the land cover within each mapping unit being compared. The assignment of land cover should be specified (e.g. does it come from a global map like GlobCover).
36.	Time series of LAI product estimates should be graphed together with in-situ values, with appropriate error bars, for both.
37.	Temporal precision of LAI estimates should be reported objectively as a histogram of retrievals over an area.
38.	The deviation of a centre sample from a linear fit of adjacent samples in time should be summarized and reported on a seasonal basis by land cover class and

	biome.
39.	The shift in LAI for evergreen targets during snow to snow-free transitions should be quantified and reported as a global map and values should be extracted for BELMANIP2 sites.
40.	Statistics related to precision of low temporal frequency LAI estimates should be developed and implemented once they have been tested with synthetic datasets.
41.	Inter-comparisons for temporal precision should be performed by comparing cumulative totals of monthly LAI over each given year.
42.	Inter-comparisons for stability should be performed using robust trend line fits across years of annual LAI totals for products with as long a temporal extent as available. Histograms of differences in slopes across biomes and land cover types represented in BELMANIP2 sites should be reported.