LAND PRODUCT VALIDATION

SUBGROUP REPORT

F. Baret, S. Garrigues & J. Nightingale

WGCV-29 Avignon September 2008

Outline

- *objectives and structure*
- *accomplishments and ongoing activities*
- *contribution to GEO tasks*
- *planed activities*
- *recommendations*

Mission Statement & Goals

- to foster **quantitative validation** in a traceable way of *higher level global land products* derived from remote sensing data and relay results so they are relevant to users

- to increase the **quality and efficiency** of global satellite product validation *via* developing and promoting international standards and protocols for field sampling, scaling, error budgeting, data exchange

- to provide feed-back to international structures (GEO/GEOSS) for :
  - requirements and achievements on product accuracy and quality assurance
  - definitions of future mission

Products targeted

- Land cover
- Fire (active, burnt area)
- Biophysical characteristics (LAI, fAPAR, fCover, chlorophyll, phenology?)
- Energy (albedo, short and long wave fluxes, (T° ?))
- Soil (moisture, type)

Products not targeted

- Net Ecosystem Exchange/Productivity (NEE/NEP)
- Evapotranspiration

LPV structure

- **A structural problem:**
  - biophysical products are not as close to sensors as radiometric calibration is!!
  - Community is large and scattered: more focus on product families corresponding to a better identified (unified?) community (land cover, fire, biophys. , energy, soil)
- **A possible solution: sub-sub-groups**
  - Land cover (M. Herold, M. Friedl?)
  - Fire (K. tansey, C. Justice ?)
  - Biophysical characteristics (R. Fernandes, Nasa ?)
  - Energy (G. Shaepman, C. Schaaf?)
  - Soil (W. Wagner, Y. Kerr?)

Outline

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Outline

- *objectives and structure*
- *accomplishments and ongoing activities*
- *current/future challenge*
- *recommendations*

LPV web site maintenance

Thanks to Jaime Nickeson and Jeff Morissette

web curator: Jaime Nickeson, NASA GSFC

Previous workshops

1) 7-8 June 2001 LAI Intercomparison
ESA Frascati, Italy
2) 23-24 October 2002 Land Product Validation Workshop on Surface Albedo
Boston MA USA
3) 16 August 2004 EOS LAI Intercomparison Activity Results
Missoula, MT USA
4) 27-28 October 2005 Global Vegetation Continuous Fields Validation Workshop
Brookings, SD USA
5) 27-28 April 2005 LPV workshop on albedo
Vienna, Austria
6) 7 August 2006 LPV workshop on long-term VI record
Missoula Montana
7) 8-10 August 2006 Long term global monitoring using moderate resolution satellites
Missoula Montana
8) 23 March 2007 LPV workshop on LAI and fAPAR products
Davos, Switzerland

9) GOFC-GOLD Land cover Symposium 14-15 October

LAI validation exercise: refinements and outreach

- **LAI measurements**
  - Garrigues, S., N. V. Shabanov, et al. (2008). "Intercomparison and sensitivity analysis of Leaf Area Index retrievals from LAI-2000, AccuPAR, and digital hemispherical photography over croplands." *Agricultural and Forest Meteorology* **148: 1193-1209.**
- **LAI Intercomparison / Direct validation**
  - Weiss, M., F. Baret, S. Garrigues, R. Lacaze, and P. Bicheron. 2007. LAI, fAPAR and fCover CYCLOPES global products derived from VEGETATION. part 2: Validation and comparison with MODIS Collection 4 products. *Remote sensing of Environment*, 110:317-331.
  - Garrigues, S., R. Lacaze, F. Baret, J. Morisette, M. Weiss, J. Nickeson, R. Fernandes, S. Plummer, N. V. Shabanov, R. Myneni, and W. Yang. 2008. Validation and Intercomparison of Global Leaf Area Index Products Derived From Remote Sensing Data. *Journal of Geophysical Research*, 113 (GO2028).

LAI Validation: conclusion

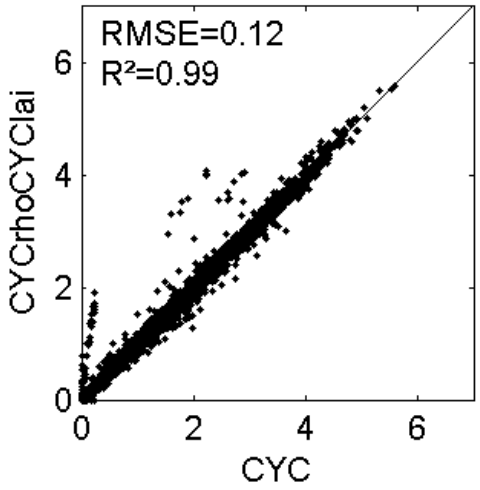
- **Methods have been developed and published**
- **Methods have been applied and results published**
- **But…**
  - Need updates with new products versions : OLIVE on line validation exercise
  - Small number of validation sites: continuous increase of number of sites (new sites and inclusion of processed archive sites) to get closer to stage 3 validation
  - Very little ‘continuous’ ground LAI measurements: PAR@METER devices
  - Revise BELMANIP: lack of inter-pixel homogeneity for some sites
  - Application to other products: fAPAR, albedo

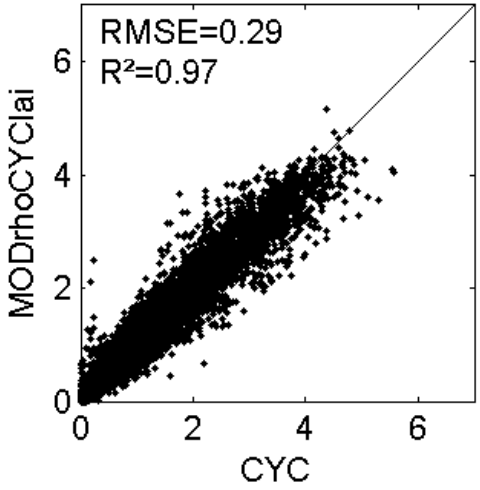
development of virtual constellation products

- **Objectives**
  - **Develop consistent products from several sensors to allow simple fusion**
- **Approach**
  - **neural networks trained with different inputs (sensors) but same outputs (products)**
  - **Application to CYCLOPES/VEGETATION and MODIS**
- **Interest**
  - **No need for absolute reflectance calibration or strong spectral consistency between sensors: just temporal and spatial stability!**
  - **Need good geometrical consistency**
  - **Application over instantaneous observations (including or not atmosphere)**
- **Results published:**
  - Verger, A., F. Baret, and M. Weiss. 2008. Efficiency of neural networks for consistent calibration of LAI products from input reflectance coming from several sensors: Application to CYCLOPES/VEGETATION and MODIS data. *Remote Sensing of Environment*, 112(6):2789-2803.
- **Implementation** in GEOLAND2 project (EC) for Long Time Series products (VEGETATION/AVHRR)

Results

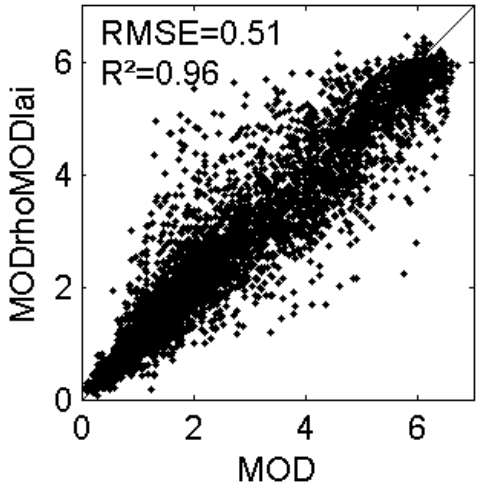
Learning CYCL. LAI with VGT data

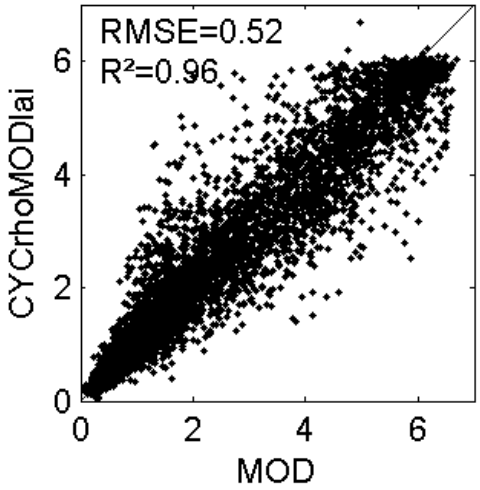




Learning CYCL. LAI with MOD. data

Learning MOD. LAI with MOD. data





Learning MOD. LAI with VGT data

Update BELMANIP: BELMANIP2

- **Objectives:**
  - propose an ensemble of sites representative of vegetation type and state for inter-comparison
  - Sites should be:
    - Flat
    - Homogeneous at 1 km scale (inter pixel variance limited)
- **First version of BELMANIP**
  - compilation of currently existing sites: AERONET/FLUXNET/DIRECT … COMPLET !
  - Work published: Baret, F., J. Morissette, and 7 co-authors. 2006. Evaluation of the representativeness of networks of sites for the global validation and inter-comparison of land biophysical products. Proposition of the CEOS-BELMANIP. *IEEE Transactions on Geoscience and Remote Sensing*, 44:1794-1803.
- **Problems identified**
  - Several sites seen ‘homogeneous’ (same class between neighboring pixels) by ECOCLIMAP (1km) were not!


Haibei(146)
Image © 2006 TerraMetrics
Google

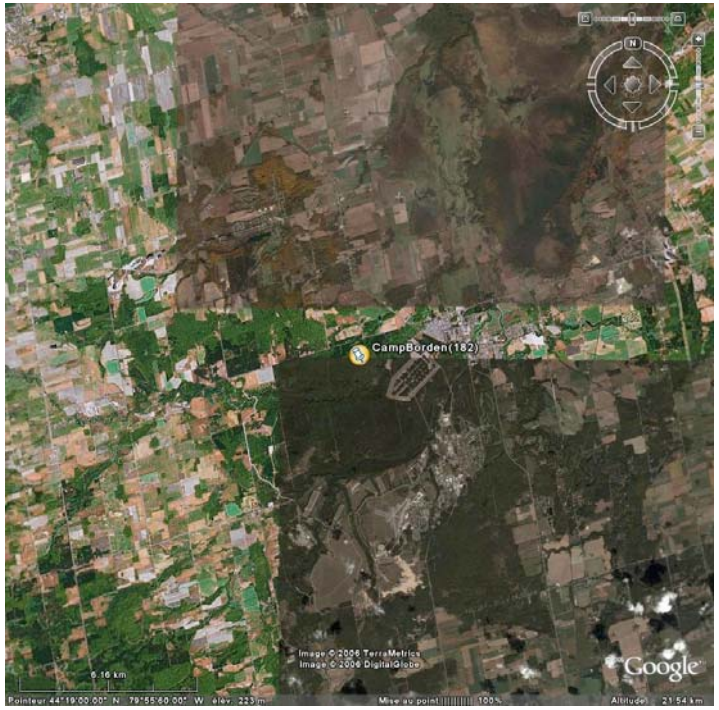

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Image © 2006 TerraMetrics
Image © 2006 DigitalGlobe
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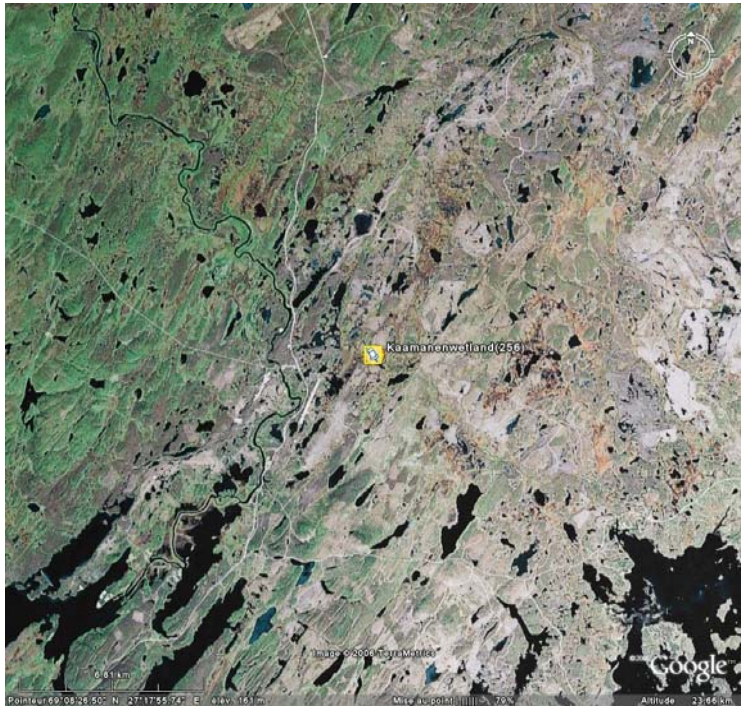
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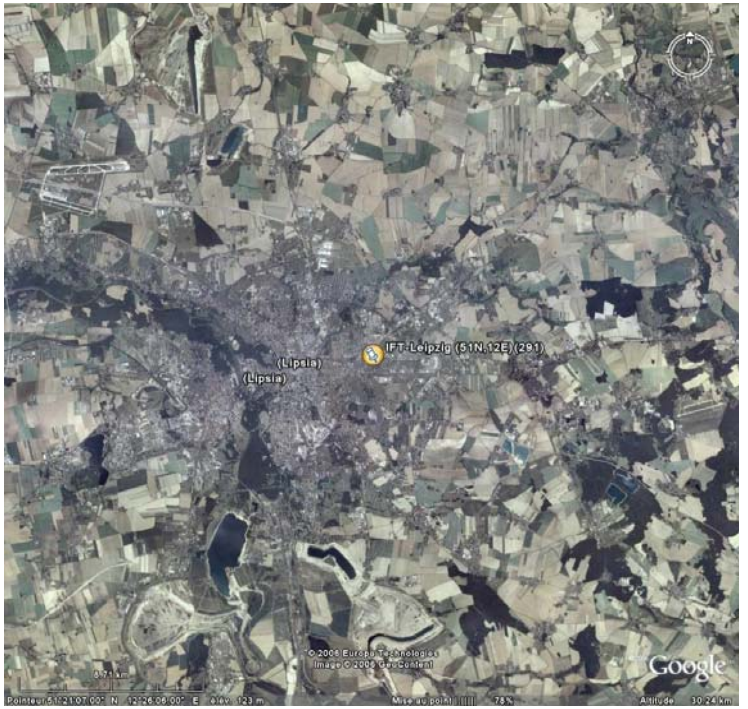
Google


IFT-Leipzig (51N,12E) (291)
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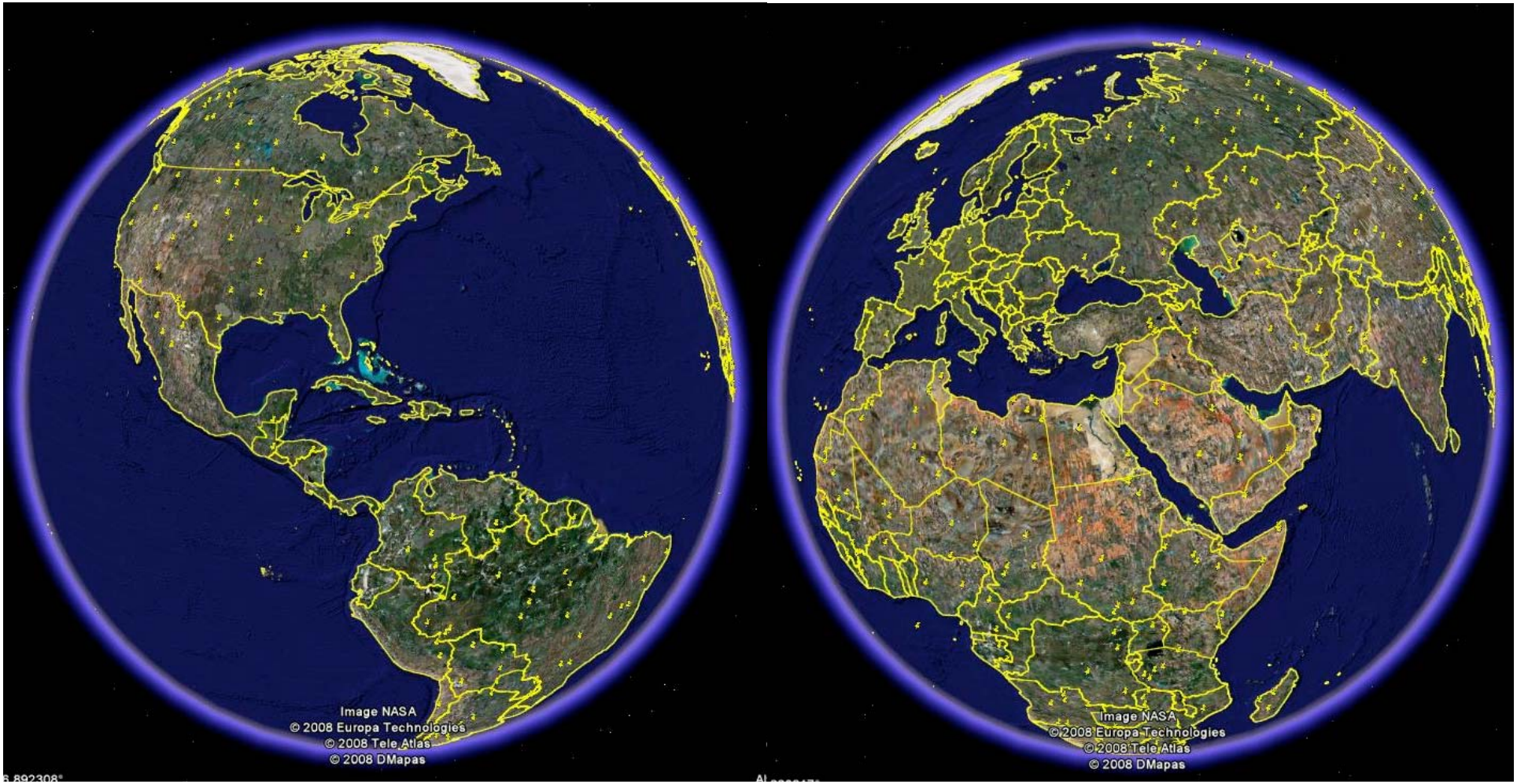
Google

BELMANIP2

- Site selection principles:
  - Divide latitude by 10° strips
  - Compute land cover (GLC2000 6 classes)
  - Select ‘pseudo’ randomly sites (number of sites proportional to frequency of GLC2000) for each class in ‘homogeneous’ (1km) places
  - Check with Google earth homogeneity and refine selection if necessary
- Current status:
  - Sites selected (
  - Evalution of representativity on going
  - Paper describing BELMANIP2 (short letter) in preparation

BELMANIP2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OLIVE

- Successive versions (collections) of products
- New products
- Traceability / transparency
- Consensus framework for validation
- Capitalization of information
  - For the products evaluated
  - For the ground measrements
- Easy access for the community

- **development of OLIVE:**

  On Line **I**nteractive **V**alidation **E**xercise

  - Supported by ESA

Characterization of products PSF

- Confusion between sampling interval and actual spatial resolution
- PSF known at the sensor level … but several processes degrades sensor PSF
- PSF required for
  - Validation
  - Fusion
    - Between products
    - With other information
- On going work over VEGETATION, MODIS and MERIS fAPAR products

Ongoing validation activities

- LAI and fAPAR validation
  - 3x3 km sites
  - Products included
    - MODIS collection 5
    - CYCLOPES V3.1
    - GLOBCARBON
    - MERIS (G-POD extraction)
  - Methodology
    - Inter comparison over BELMANIP2
    - Direct validation with distinction between effective and ‘true’ values for LAI
- M. Weiss, S. Garrigues, F. Baret, R. Lacaze

Development of continuous fAPAR and LAI measurement systems

- Current situation
  - Most sites currently instrumented/sampled correspond to ‘one shot’ measurements
  - Need for sampling different development stages / states of the vegetation
  - Interest in seasonality (canopy functioning)
  - Classical systems with sensors connected to a data logger exist but:
    - They are expensive (data logger)
    - Difficult to install/desinstall (wires)
- Development of a wireless affordable system (PAR@METER)

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Contribution to GEO Tasks

Several tasks share same contributions from LPV.

Area	Task #	Task Title	Proposition for potential contribution from LPV	LPV achievements	Contact	References
Agriculture	AG-05-04	Forest Mapping and Change Monitoring	1) Recommendations for Evaluation and Accuracy Assessment of Global Land Cover Maps; 2) Proposition of using biophysical products for change detection.	1) LPV with GOFC-GOLD contributed to this task by encouraging coordinated developments and providing the framework for evaluation of Global Land Cover maps. Documents were written that report methodology and results for the validation of land cover maps. 2) To be discussed and tested	Alan H. Stehler, Philippe Mayaux, LPV chair	1, 2, 3, 4
Agriculture	AG-07-01	Improving Measurements of Biomass	1) provide accuracy evaluation of inputs to vegetation productivity models 2) provide recommendations for accuracy assessment of productivity, gross primary production and biomass	1) Biophysical variables such as LAI and fAPAR are key inputs to vegetation productivity models. LPV has been focusing on those variables, by (i) proposing a clear and consensus definition of these variables, (ii) describing departure of available products from the main definition, (iii) developed of a methodological framework for accuracy assessment of products, and (iiii). Results on evaluation of medium spatial resolution LAI products accuracy from ground measurements and intercomparison between available products. 2) Discussions started at Global Vegetation Monitoring meeting (Missoula 2008) and papers published in IEEE TGARS validation special issue.	LPV Chair, Sebastien Garrigues	5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 16, 17
Climate	CL-06-02	Key Climate Data from Satellite Systems	1) Provide accuracy statements for Essential Climate Variables (ECVs) as defined in the GCOS Implementation Plan for the terrestrial domain. Emphasis on land cover, Albedo, LAI, fAPAR, Fire and soil moisture products from medium resolution sensors.	1) LPV with GOFC-GOLD contributed to validate global land cover maps. Similarly, LPV contributed in the validation of LAI, fAPAR and fire products.	LPV chair	18, 8
Climate	CL-06-03	Key terrestrial observations for	2) Propose strategies to exploit in a consistent way historical satellite archive and derive long time series of products.	2) LPV proposed strategies to build consistent long time series of biophysical variables		20
Data Management	DA-06-02	GEOSS Quality Assurance Strategy	1) Provide a strategy and methods for quality assessment of land cover (with GOFC-GOLD) fire and biophysical products derived from satellite observations. 2) Maintain easy access to key information for the validation LPV. 3) Organizes meetings to define and discuss the methods and share results with the community.	1) A strategy has been defined for the validation of higher level products: land cover (with GOFC-GOLD) and fire and LAI and fAPAR biophysical products. Results show that stage 2 of the validation is achieved, but stage 3 (quantitative accuracy assessment representative of global conditions) is not yet reached. 2) A web site is set up providing information on validation activities. Articles in peer reviewed journal have been published with results based on methods proposed within LPV. 3) Workshops have been organized to define and discuss the methods and share results with the community.	LPV chair	2, 6, 7 21, 5, 8, 9, 10, 11, 12, 13, 14, 15 21, 22, 23, 18, 5
Data Management	DA-06-04	Data, Metadata and Products Harmonisati	1) Provide strategy for harmonization of global land cover mapping 2) Provide a strategy for harmonization through intercomparison of homologous biophysical products	1) A strategy for harmonization of global land cover has been defined, allowing intercomparison of classifications and maps. 2) A strategy for intercomparing biophysical products has been proposed. Preliminary results are available for LAI and fAPAR.	Martin Herold LPV chair	2 5, 6, 7, 8, 9, 10, 11, 12, 13, 14,
Data Management	DA-07-02	Global Land Cover	1) Recommendations for Evaluation and Accuracy Assessment of Global Land Cover Maps; 2) Proposition of using biophysical products for change detection.	1) LPV with GOFC-GOLD contributed to this task by encouraging coordinated developments and providing the framework for evaluation of Global Land Cover maps. Documents were written that report methodology and results for the validation of land cover maps. 2) To be discussed and tested	Alan H. Stehler, Philippe Mayaux, LPV chair	1, 2, 3, 4
Data Management	DA-07-03	Virtual Constellations	1) Propose a strategy for intercomparison of products derived from several sensors. 2) Propose methods for merging products coming from several sensors 3) Evaluate benefit of using virtual constellation products 4) Define minimum requirements for inter-operability of sensors	1) A strategy for intercomparison of products was proposed with application to biophysical variables (LAI, fAPAR) 2) Simple solutions proposed for merging products coming from similar sensors 3) Early evaluation for albedo and BRDF products 4) Not yet achieved	LPV Chair	5, 6, 7, 8 24, 25 24, 25
Disasters	DI-05-09	Use of Satellites for Risk Management	1) Propose a strategy for intercomparison of products derived from several sensors. 2) Propose methods for merging products coming from several sensors 3) Evaluate benefit of using virtual constellation products 4) Define minimum requirements for inter-operability of sensors	1) A strategy for intercomparison of products was proposed with application to biophysical variables (LAI, fAPAR) 2) Simple solutions proposed for merging products coming from similar sensors 3) Early evaluation for albedo and BRDF products 4) Not yet achieved	LPV Chair	5, 6, 7, 8 24, 25 24, 25
Ecosystems	EC-05-01	Integrated Global Carbon Observation	1) Provide uncertainties on products used to scale up local observations to region and scale	1) Uncertainties available for few products required in the scaling up process: land cover, albedo, LAI and fAPAR	LPV Chair	21, 5, 8, 9, 10, 11, 12, 13, 14, 15
Ecosystems	EC-05-02	Ecosystem Classification	1) Propose recommendations for Evaluation and Accuracy Assessment of Global Land Cover Maps; 2) Propose to use biophysical products for change detection.	1) LPV with GOFC-GOLD contributed to this task by encouraging coordinated developments and providing the framework for evaluation of Global Land Cover maps. Documents were written that report methodology and results for the validation of land cover maps. 2) To be discussed and tested	Alan H. Stehler, Philippe Mayaux, LPV chair	1, 2, 3, 4
Ecosystems	EC-05-07	Regional Networks for	1) Development of validation of products for the monitoring of ecosystems at regional level	1) LPV developed a strategy for validation of land cover and biophysical products. Early results are available for land cover and LAI, fAPAR and albedo	LPV Chair A. Stehler P. Mayaux	1, 2, 3,4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15
Ecosystems	EC-07-01	Global Ecosystem Observation and Monitoring Network	1) Contribute to provide a global classification of ecosystems 2) Contribute to develop a global sampling scheme for ecosystem characterization and monitoring 3) Propose methods to up-scale local ground measurements to larger spatial domains	1) LPV with GOFC-GOLD contributed to this objective by encouraging coordinated development of consistent land cover mapping 2) LPV has proposed a global network of sites that samples vegetation types and conditions. It is based on existing thematic networks such as AERONET or FLUXNET and sites where ground measurements are collected for the direct validation of medium resolution biophysical products. Agencies agreed to provide extracts of medium resolution products they are in charge 3) In the framework of the validation of medium resolution products, up-scaling methods have been developped to extend over larger spatial domains a set of local ground measurements and qualify the spatial sampling used. These methods are based on high spatial resolution images	LPV chair	1, 2, 4 7 6, 26, 9, 10, 11, 12
Weather	WE-06-02	Space-based Global Observing System for Weather	1) Provide accuracy statements for Essential Climate Variables (ECVs) as defined in the GCOS Implementation Plan for the terrestrial domain. Emphasis on land cover, Albedo, LAI, fAPAR, Fire and soil moisture products from medium resolution sensors. 2) Propose strategies to exploit in a consistent way historical satellite archive and derive long time series of products.	1) LPV with GOFC-GOLD contributed to validate global land cover maps. Similarly, LPV contributed in the validation of LAI, fAPAR and fire products. 2) LPV proposed strategies to build consistent long time series of biophysical variables	LPV chair	18, 8 20

Contribution to DA-06-04

GEO Task # (DA-06-04): Data, Metadata an d Products Harmoni zation

CEOS Agency : CEOS/WGCV

Point of Contact : WGCV chair , WGCV/LPV chair

1. Identify current activities contributing to this task, and the significance.

This task is addressed by WGCV under DA -06-02: Developing a data quality assurance strategy for GEOSS (see the questionnaire for DA -06-02 for more details). In addition, the WGCV/LPV (Land Product Validation) subgroup is address ing this task as follows:

1) Provide strategy for harmonization of global land cover mapping

2) Provide a str ategy for harmonization through intercomparison of homologous biophysical products

2. Identify actions and/or deliverables related to the activities described above (these actions will be reported to CEOS). What is the identifiable result of the action?

(May be a multiyear activity , however please include action/deliverable to be completed in 2008).

- Results on global LAI products validation: a paper was just recently accepted: Garrigues, S., R. Lacaze, F. Baret, J. Morisette, M. Weiss, J. Nickeson, R. Fern andes, S. Plummer, N. V. Shabanov, R. Myneni, and W. Yang. 2008. Validation and Intercomparison of Global Leaf Area Index Products Derived From Remote Sensing Data. Journal of Geophysical Research, accepted.

- Strategy for generating consistent biophysica l products from available medium resolution sensors. A pilot study has been completed to show how LAI could be generated in a consistent way from several sensors with application to MODIS and VEGETATION. This study shows that most of the effort should be c oncentrated on the generation of the best possible learning data base. A paper was recently accepted: Verger, A., F. Baret, and M. Weiss. 2008. Efficiency of neural networks for consistent calibration of LAI products from input reflectance coming from seve ral sensors: Application to CYCLOPES/VEGETATION and MODIS data. Remote Sensing of Environment, accepted for publication.

- Up date BELMANIP network of sites: current BELMANIP sites are often relatively heterogeneous. They were mainly selected from already existing networks (FLUXNET, AERONET, …). An up -date will be achieved to improve site homogeneity and representativeness. This network of sites is used for intercomparison of biophysical products. The lis of sites and description will be posted on the LPV site.

- Quantifying point spread function (PSF) of current biophysical products. PSF of instruments are generally well known, but could not directly transfer to higher level products PSF because of the several processing steps that degrade sensor PSF: int erband registration, projection (and interpolation), interdate registration, effect of view angle, …A study is currently ongoing to provide users of biophysical products with estimates of the associated PSF. It should be submitted to a peer reviewed journ al before the end of the year (presumably RSE).

- Evaluation of several global land cover classification at regional scale. An on going study on landscape physiognomy evolution achieved over Michoacan (Mexico) will first concentrate on comparison of curre nt global classification with ground level survey. Results will be reported in a peer reviewed journal with emphasis on consistency and accuracy of these land -cover products.

- fAPAR definition, ground measurements and Evaluation of global products. Altho ugh albedo has received a lot of attention for its definition, fAPAR has only received little attention while both products are subjected to similar problems. An ongoing study will provide a framework for fAPAR definition and describe how fAPAR could be me asured from ground level. A paper will be written in peer reviewed journal. Additionally, the main fAPAR products (MODIS C5, CYCLOPES V4 and JRC fAPAR) will be intercompared. Methods and results will be presented in a peer reviewed journal (presumably RSE of JGR).

1. Identify any issues (current/potential data gaps, data sharing problems , funding , etc)

- Funding requested to extend ground validation measurements and exploitation of already existing data sets.

- Need for development of on line validation biop hysical product tool: funding and web site management

These issues will be discussed at WGCV28 and addressed at WGCV29 in Sept. 08, to be hosted by the LPV chair .

2. Identify actions and/or deliverables needed to address the issues described above (these actions will be reported to CEOS). Specify when action needs to be completed . What is the identifiable result of the action?

-WGCV/LPV issues will be discussed at WGCV28 and addressed at WGCV29 in Sept. 08, to be hosted by the LPV chair .

3. Identify key intern ational organization (s) already assigned to work on this task fr om the satellite perspective. Are there any outstanding issues CEOS can help address in coordination with these organization(s).

-NASA, INRA, CNES, ESA, USGS , NOAA,

Contribution to DA-07-03

GEO Task # (DA-07-03): Virtual constella tion

CEOS Agency : CEOS/WGCV

Point of Contact : WGCV chair , WGCV/LPV chair

1. **Identify current activities contributing to this task, and the significance.**
   1) Propose a strategy for intercomparison of products derived from several sensors.
   2) Propose methods for merging products coming from several sensors
   3) Evaluate benefit of using virtual constellation products
   4) Define minimum requirements for inter -operability of sensors

2. **Identify actions and/or deliverables related to the activities described above (t hese actions will be reported to CEOS). What is the identifiable result of the action?**
   (May be a multiyear activity , however please include action/deliverable to be completed in 2008).

- A strategy for intercomparison of products was proposed (see DA -06-04)

- Strategy for generating consistent biophysical products from available medium resolution sensors. A pilot study has been completed to show how LAI could be generated in a consistent way from several sensors with application to MODIS and VEGETATION. T his study shows that most of the effort should be concentrated on the generation of the best possible learning data base. A paper was recently accepted: Verger, A., F. Baret, and M. Weiss. 2008. Efficiency of neural networks for consistent calibration of L AI products from input reflectance coming from several sensors: Application to CYCLOPES/VEGETATION and MODIS data. Remote Sensing of Environment, accepted for publication.

- Quantifying point spread function (PSF) of current biophysical products. Product PSF is required to better define the actual spatial resolution and sampling needed for merging different products. PSF of instruments are generally well known, but could not directly transfer to higher level products PSF because of the several processing s teps that degrade sensor PSF: interband registration, projection (and interpolation), interdate registration, effect of view angle,…A study is currently ongoing to provide users of biophysical products with estimates of the associated PSF. It should be s ubmitted to a peer reviewed journal before the end of the year (presumably RSE).

3. **Identify any issues (current/potential data gaps, data sharing problems , funding , etc)**

- Need to develop data fusion algorithm: temporal compositing of products coming from several sensors: funding required
- A structure to develop products derived from the fusion of already existing medium resolution sensors is needed.
These issues will be discussed at WGCV28 and addressed at WGCV29 in Sept. 08, to be hosted by the LPV chai r.

4. **Identify actions and/or deliverables needed to address the issues described above (these actions will be reported to CEOS). Specify when action needs to be completed . What is the identifiable result of the action?**

-WGCV/LPV issues will be discussed at WGCV28 and addressed at WGCV29 in Sept. 08, to be hosted by the LPV chair .

1. **Identify key international organization (s) already assigned to work on this task fr om the satellite perspective. Are there any outstanding issues CEOS can help address in coordin ation with these organization(s).**
   -NASA, INRA, CNES, ESA, USGS , NOAA, EUMETSAT

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Planed activities (1/2)

- **Future meetings**
  - Albedo meeting March 2009 (Beijing) or October 2009 (London)
  - Biophysical products June 2009 Montana
  - Fire products 2009 ?
  - Soil moisture (SMOS/SMAP) TBD 2010?
  - Temporal signature in remote sensing. January 2010
- **Continue collecting ground validation**
  - GEOLAND2 (EC)
    - Compilation of existing (not compiled) sites
    - Develop new sites (4)
  - TRUTH (ESA)
  - ?? Are flux sites well suited?

Planed activities (2/2)

- **Setup the OLIVE tool**
- **Publication**
  - Publish BELMANIP2
  - Publish LAI/fAPAR validation
  - Publish PAR@METER results
  - Publish on OLIVE

- **Continue investigating methods to build virtual constellations**
  - **Medium spatial resolution (GEOLAND2)**
    - **MODIS / VEGETATION / MERIS / AVHRR**
  - **High spatial resolution**
    - **SPOT / Landsat / DMC / Rapid-eye / Formosat**

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Recommendations

- **Monitoring progress of previous recommandations**
  - Recommend agencies to support the continuity and expansion of product validation activities to be able to quantify the associated uncertainties and allow fusion between similar products
    - *A lot of progress still needed (except ESA (TRUTH) and EC (GEOLAND2))*
  - Encourage agencies to prepare subsets or develop tools for data/products extraction for validation activities
    - *A lot of progress for ESA and VITO (US very good)*
  - Need more consistency in geometrical formats (grid/projection/datum)
    - *To be changed into a more precise recommendation*
  - Need support for implementation of the 'on line validation tool' in the CAL/VAL portal
    - *ESA will support this activity*
- **New recommendations**
  - Encourage agencies to develop easy to use, open source, software tools for (re)projecting any product in (at least) the main projection systems used.