LAND PRODUCT VALIDATION

SUBGROUP REPORT

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WGCV-28 Sanya February 2008

Outline

- *accomplishments since last WGCV*
- *relevance to the CEOS/IP or GEO task*
- *current/future challenge*
- *requested agency commitments.*

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

LAI validation exercise: refinements and outreach

- Discussed during Missoula and Davos meetings
- 2 papers published
  - 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.

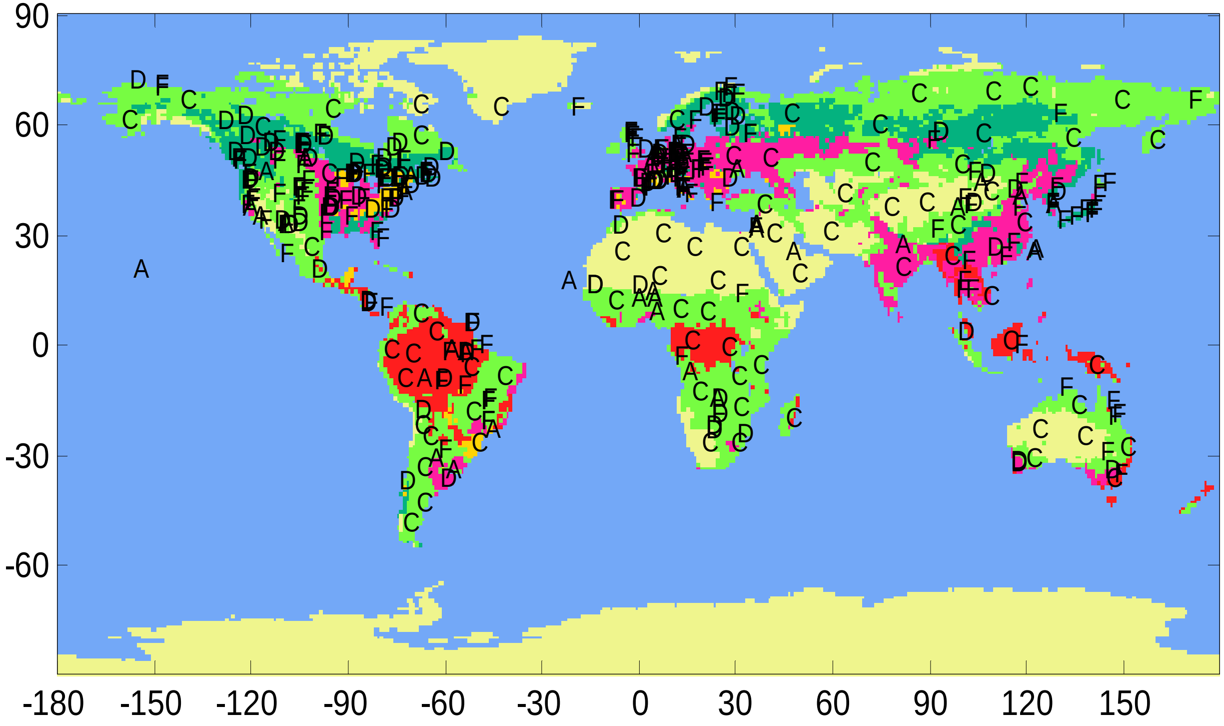
  - Garrigues, S., R. Lacaze, F. Baret, J. Morisette, M. Weiss, J. Nickeson, R. Fernandes, S. Plummer, N. V. Shabanov, R. Myneni, and W. Yang. 2008. Validation and Intercomparison of Global Leaf Area Index Products Derived From Remote Sensing Data. *Journal of Geophysical Research*, accepted.

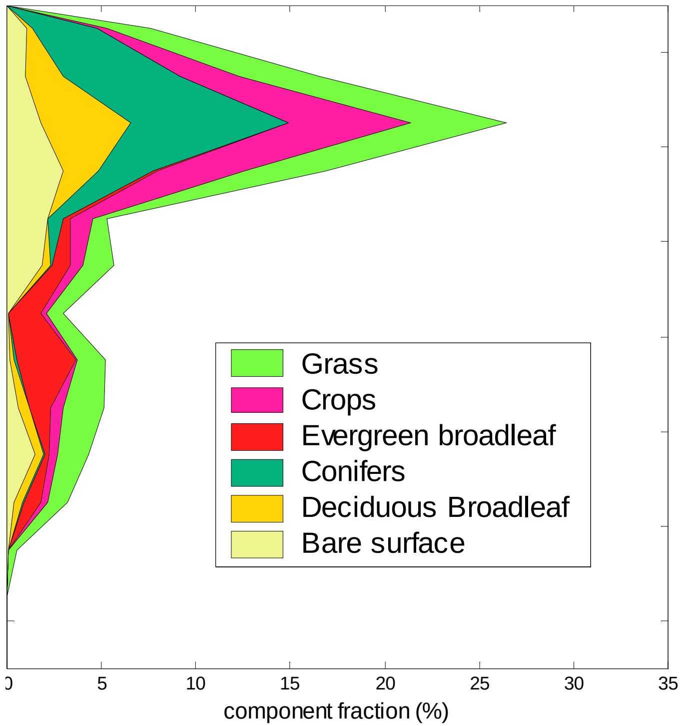
Products considered

Product name	GSD	Temporal Sampling	Algorithm	Parameterization	Clumping representation			Seasonal smoothing	References
					Plant/Shoot	Canopy	Landscape		
CYCLOPES-V3.1	1/112°	10 days	RTM 1D (neural network)	Global	No	No	Yes	No	Baret *et al.*, 2007
ECOCLIMAP	1/120°	1 month	Empirical (based on NDVI variations)	Vegetation type	Yes	Yes	No	No	Masson *et al.*, 2003
GLOBCARBON	1/11.2°	1 month	Model derived VI-LAI relationship	Vegetation type	Yes	Yes	No	Yes	Deng *et al.*, 2006
MODIS-C4	1km	8 days	Main Alg: RTM 3D (LUT) Backup: LAI-NDVI empirical relationship	Vegetation type	Yes	Yes	Yes	No	Knyazikhin *et al.*, 1998; Myneni *et al.*, 2002
CCRS	1km	10 days	Empirical VI-LAI relationship	Vegetation type	Yes	Yes	Up to ~1ha	Yes	Fernandes *et al.*, 2003

Consider 10x10 km² resolution
1 month time step

Intercomparison over CEOS-BELMANIP



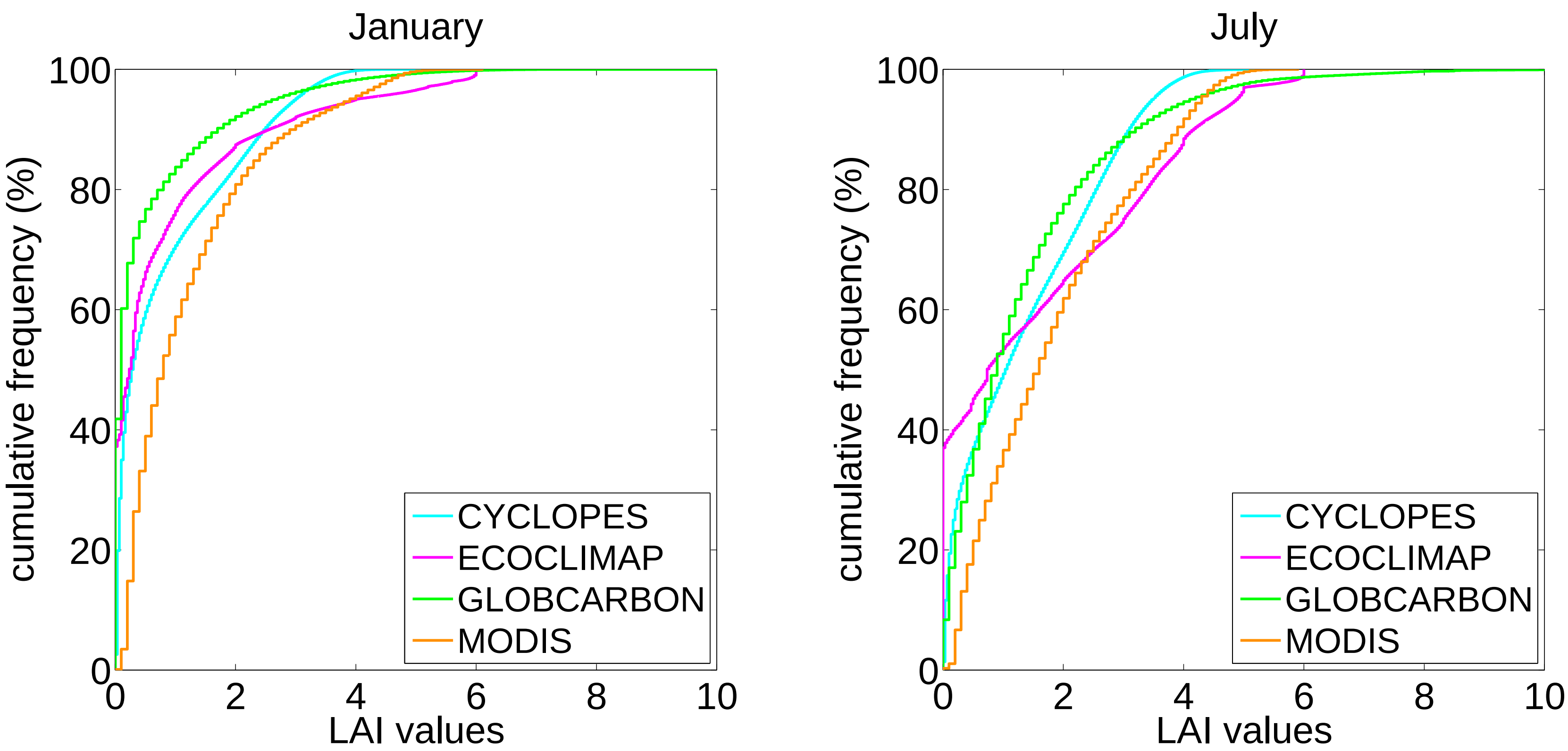


397 sites representing the variability over surface types and latitudes

Working Group on Calibration & Validation CEOS

Baret, F. et al., 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(7: special issue on global land product validation): 1794-1803.

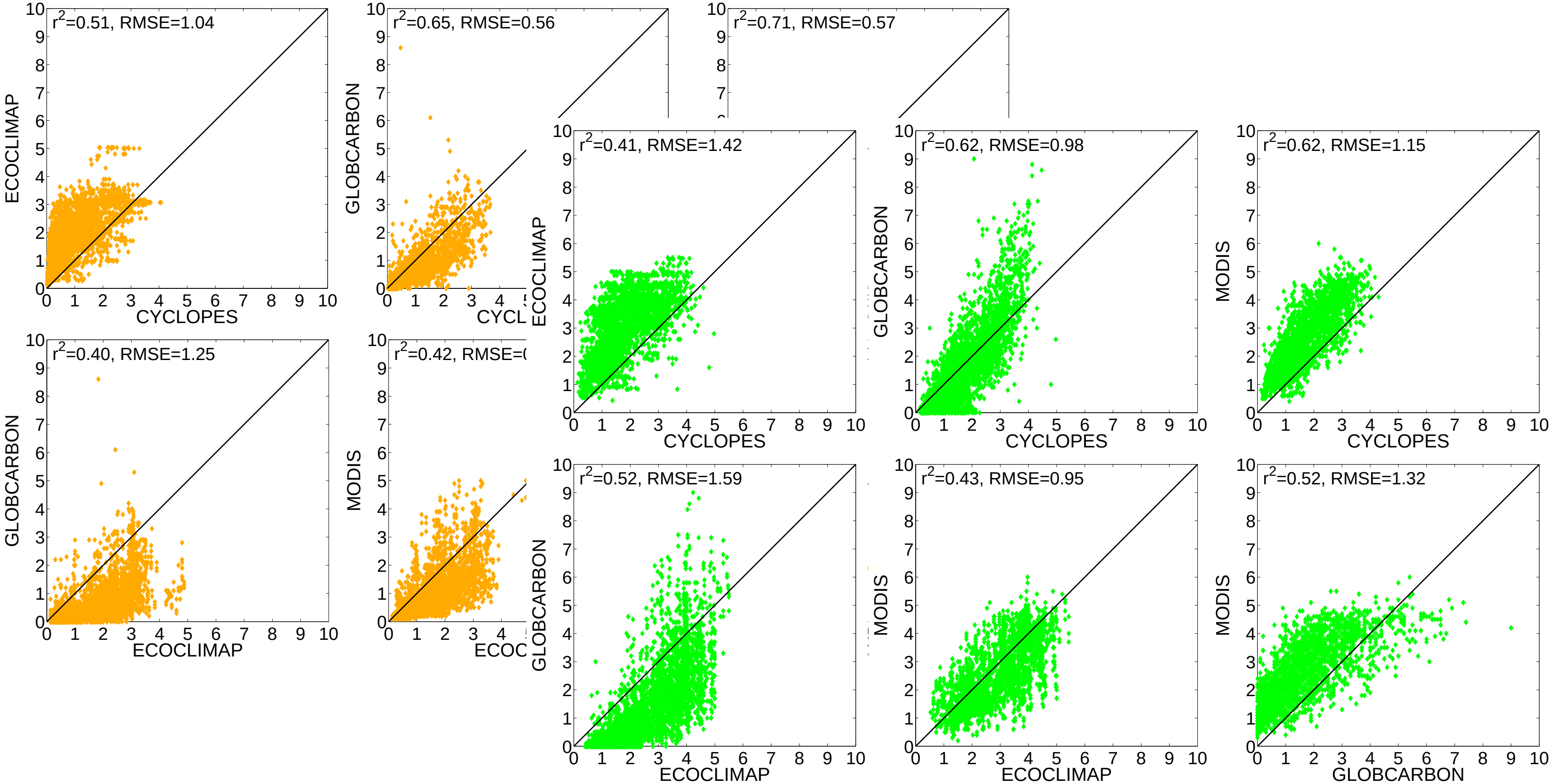
Intercomparison



Statistical distribution:

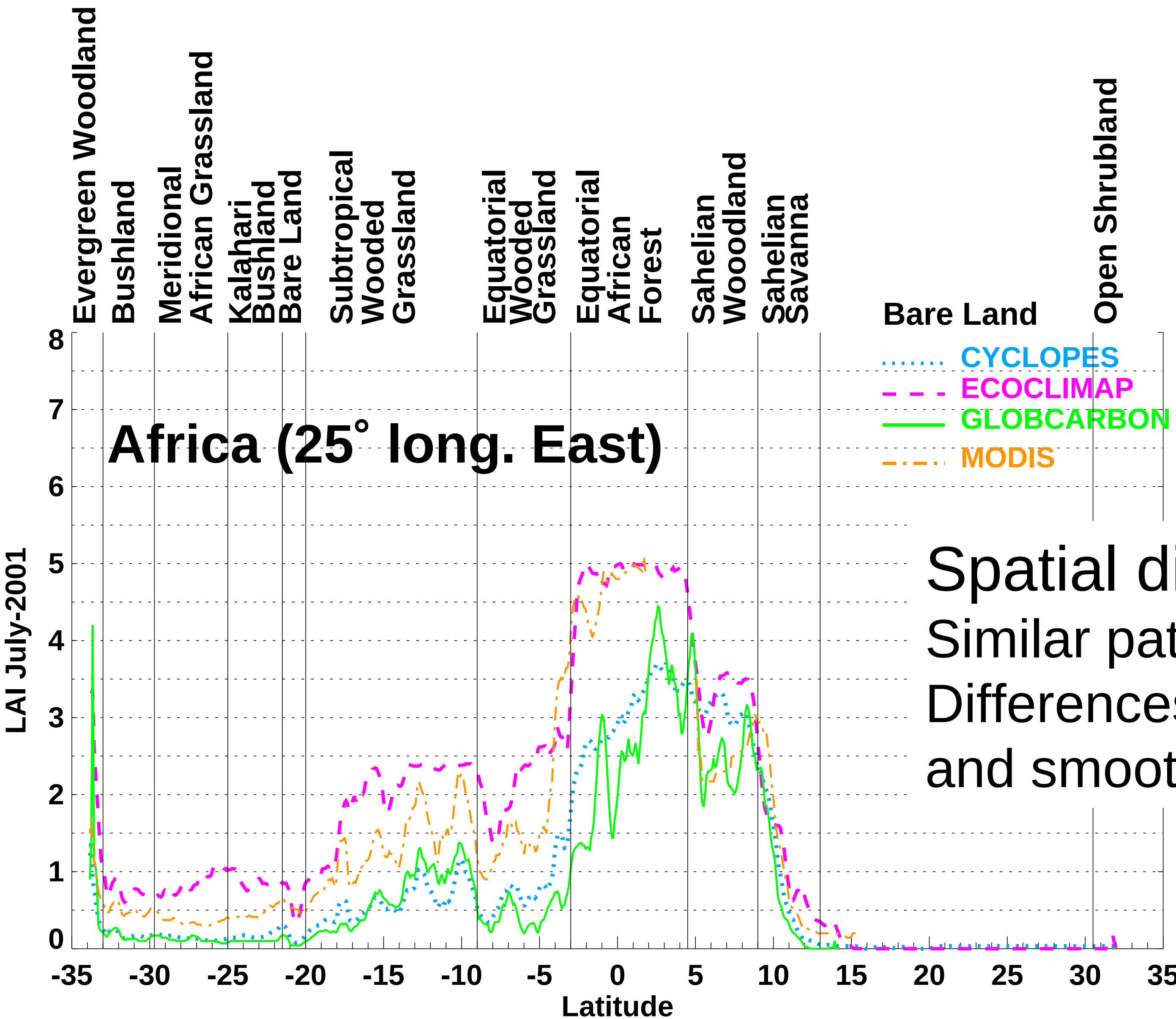
large differences between products

Intercomparison



Scatterplots: large differences depending on products and vegetation type

Intercomparison



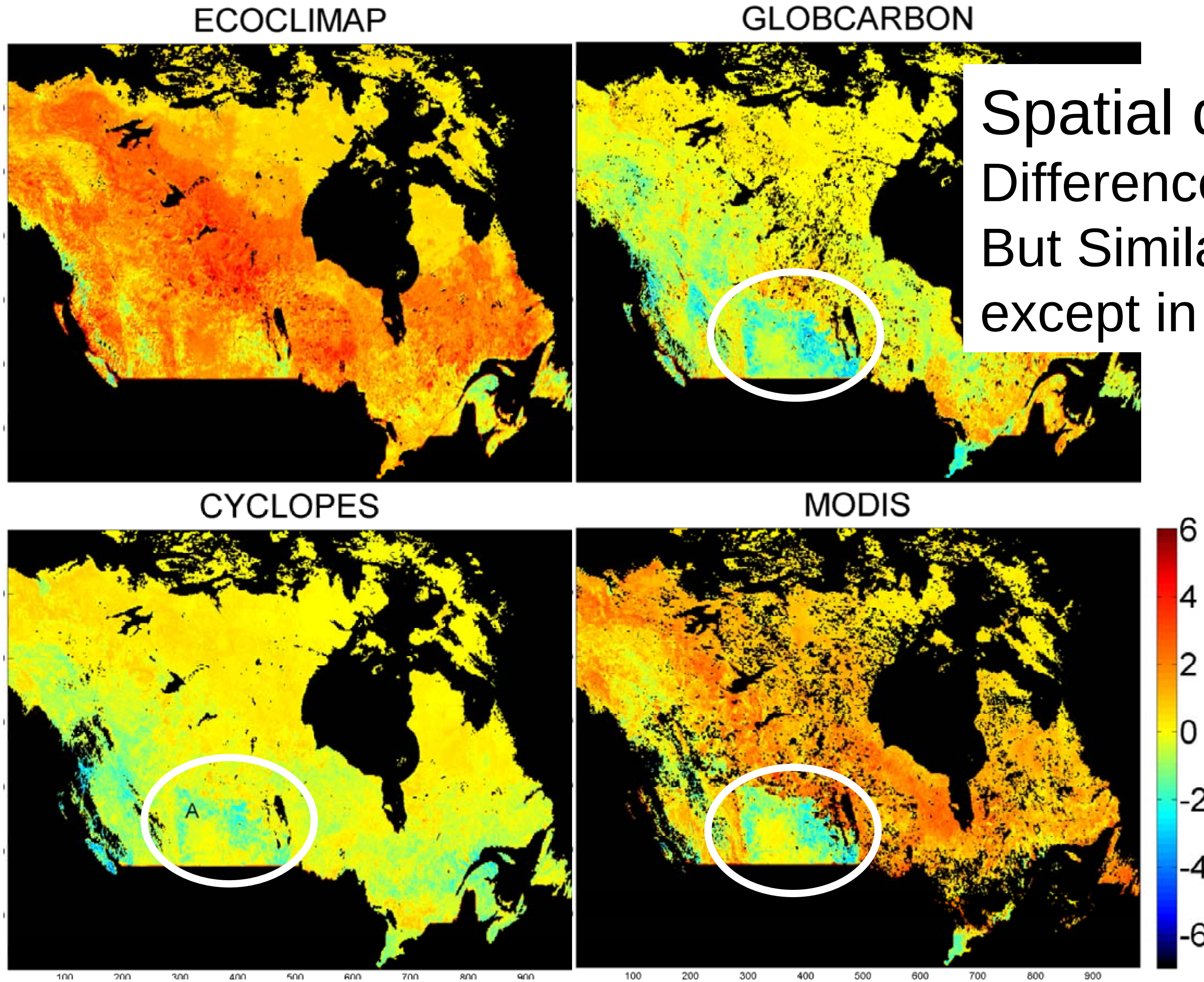
Spatial distribution:

Similar patterns but

Differences in amplitude

and smoothness

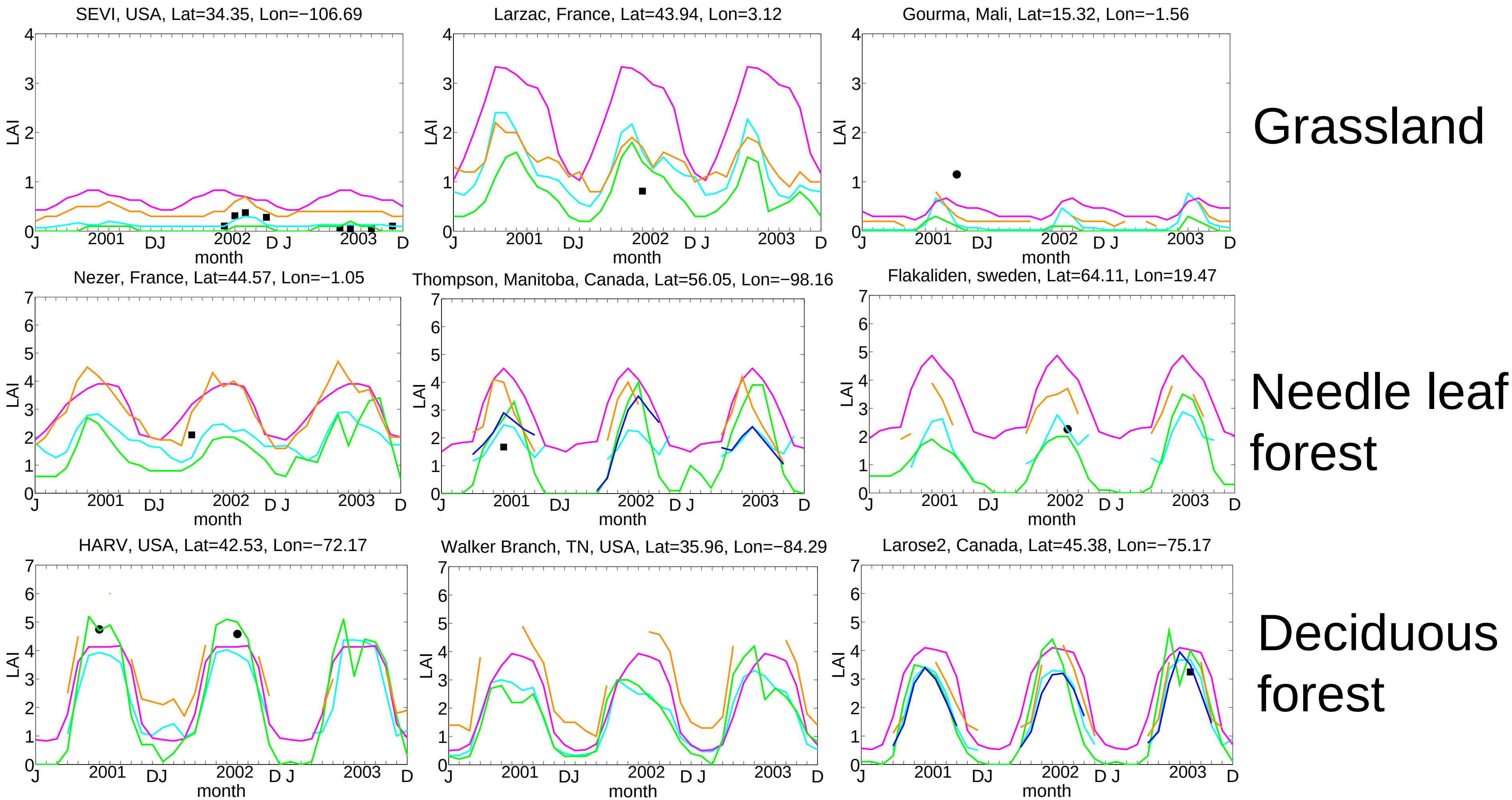
Intercomparison



Spatial distribution:
Differences in values
But Similar patterns
except in specific areas

maps of differences CCRS-Product over Canada

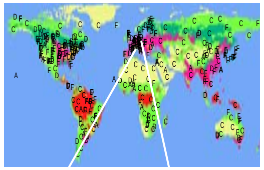
Intercomparison



Temporal distribution: similar patterns (except ecoclimap)

But differences in continuity (smoothness, gaps)

Direct validation: Comparison with ground measurements: bottom-up approach

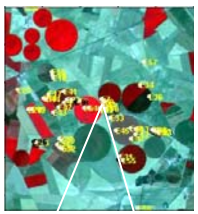


50-100 sites

Global validation

Scatter plot

Medium resolution products to be validated

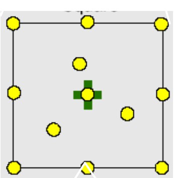


20-100 ESUs/site

Value(s) at the site level

Transfer function

High spatial resolution image (SPOT/TM/ASTER …)



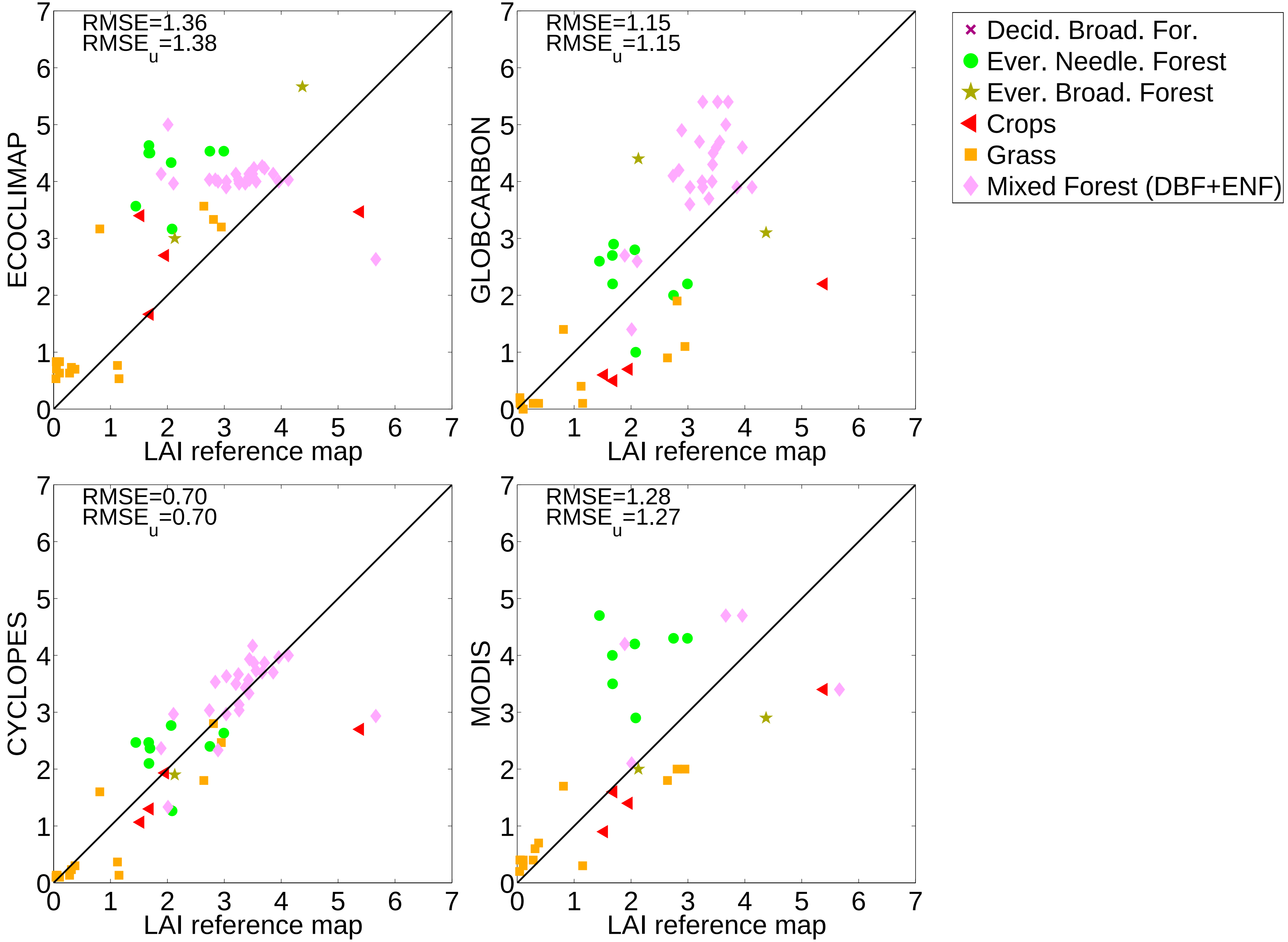
10-100 measurements/ESU

Value at the ESU level

Averaging

Individual measurements

Direct Validation: results



Synthesis

Criteria	CYCLOPES	ECOCLIMAP	GLOBCARBON	MODIS
Global distribution	+	-	+	+
Spatial consistency	+	-	-	+
Temporal consistency				
Missing data	-	+	+	-
Interannual and seasonal cycles	+	-	-	+
Magnitude of LAI				
High values	-	+	+	+
Low values	+	+	+	-
Comparison to in-situ data	+	-	-	-

LAI Validation: conclusion

- **Methods have been developed and published**
  - Morisette, J., F. Baret, and 28 co-authors. 2006. Validation of global moderate resolution LAI Products: a framework proposed within the CEOS Land Product Validation subgroup. *IEEE Transactions on Geoscience and Remote Sensing*, 44:1804-1817.
  - 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.
- **Methods have been applied and results published**
  - 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, accepted
- **But…**
  - Need updates with new products versions : 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 interpixel homogeneity for some sites
  - Application to other products: fAPAR

Towards the development of virtual constellation products

- **Objectives:**
  - Development of consistent products from several sensors to allow simple fusion
- **Framework:**
  - GEO/CEOS virtual constellation
  - GEOLAND_2
- **Approach:**
  - Evaluate the performances of neural networks when trained with several inputs and outputs
  - Application to CYCLOPES/VEGETATION and MODIS

Products used

	MODIS		CYCLOPES		NNT
	Reflectance (MOD43B4)	LAI (MOD15A2)	Reflectance (CYCL L3a)	LAI (CYCL V3.1)	resampling
spatial sampling	1km		1/112°		3 km
projection	sinus		lat-lon		sinus
geometric accuracy	50 m		140m		50-140
PSF	?	?	1920m		?-
temporal sampling	16	8	10	10	16
Temporal resolution	16	8	30	30	24-40

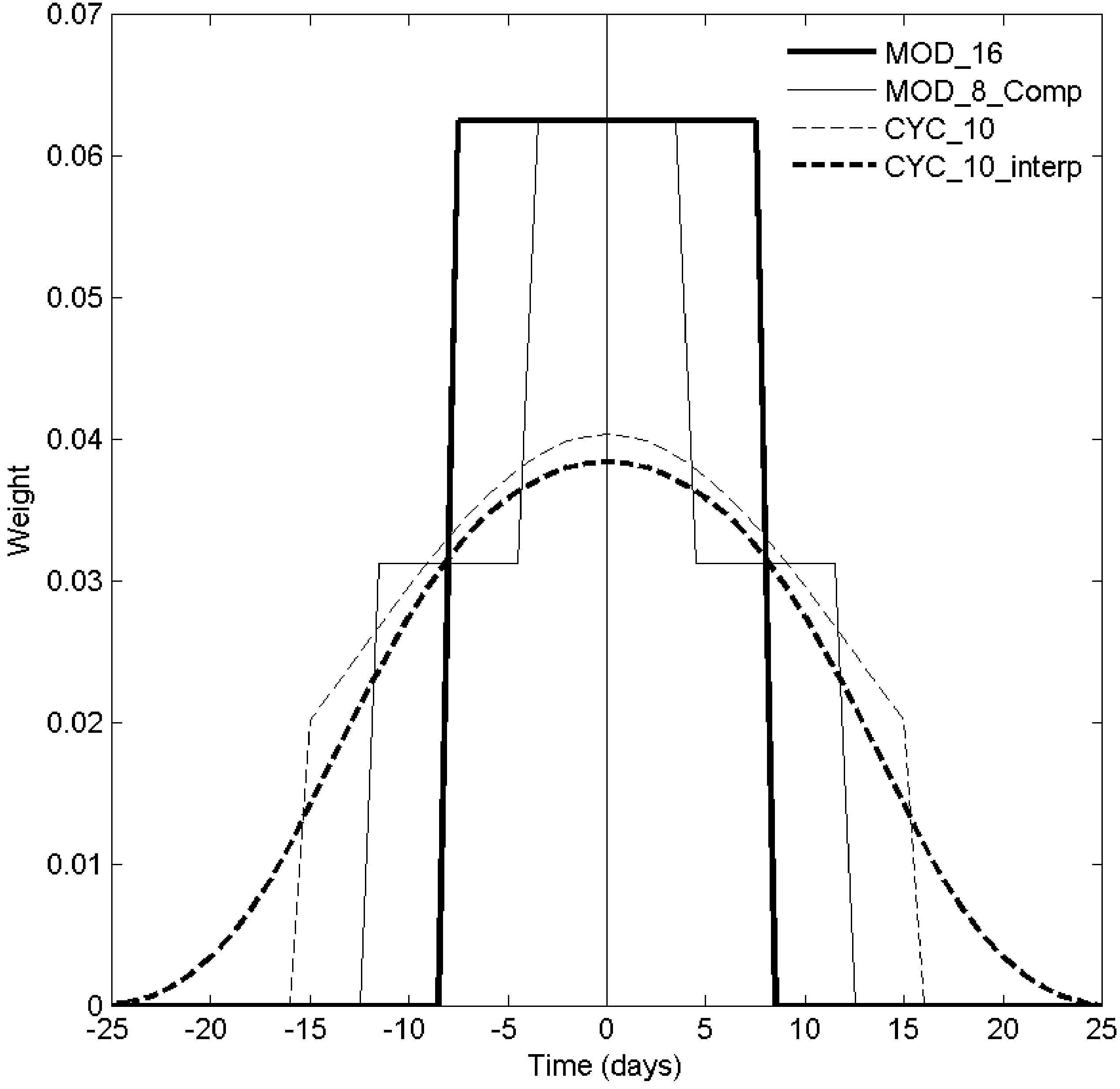
Red	620-670		610-680	
NIR	841-876		780-890	
SWIR	1628-1652		1580-1750	
Clumping		plant/canopy		landscape

Original CYCLOPES (V3.1) and MODIS (collection 4) products

Resampling necessary for better consistency of products
Filtering over the 3x3 pixels: >50% good data

Biophysical algorithm diferences for LAI
- MODIS: LUT computed from 3D RT model and tuned for 6 biome classes
- CYCLOPES: NNT trained from 1D RT model across all classes

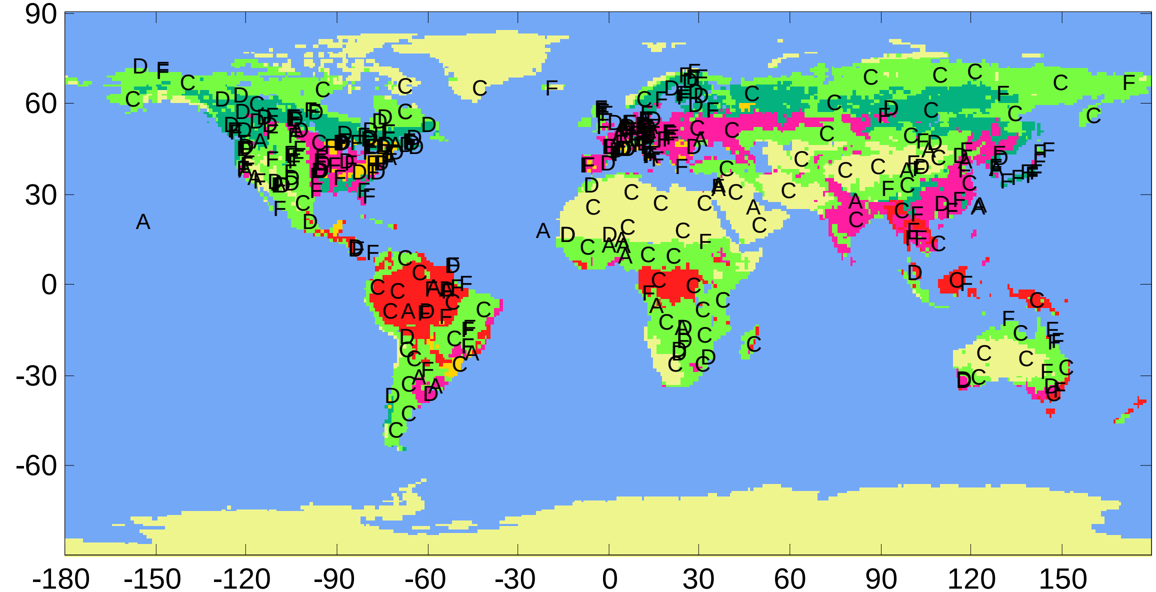
Temporal resolution



Differences in temporal resolution between MODIS and CYCLOPES

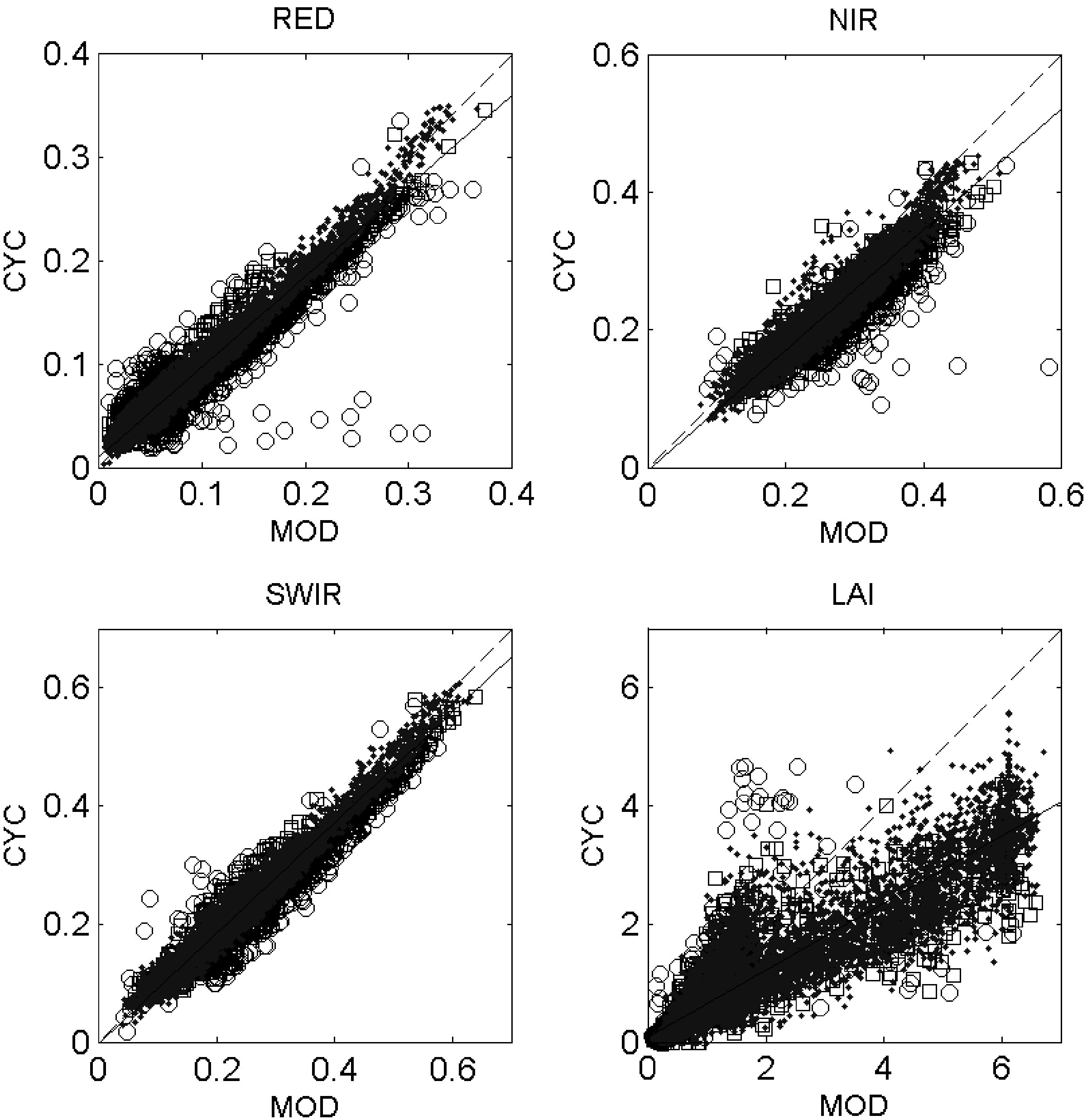
Sites sampling

- 397 BELMANIP sites



- 2001-2003 period
- Filtering:
  - 38112 potential observations
  - only 7572 matches (20%)
  - 10% ‘outliers’ eliminated

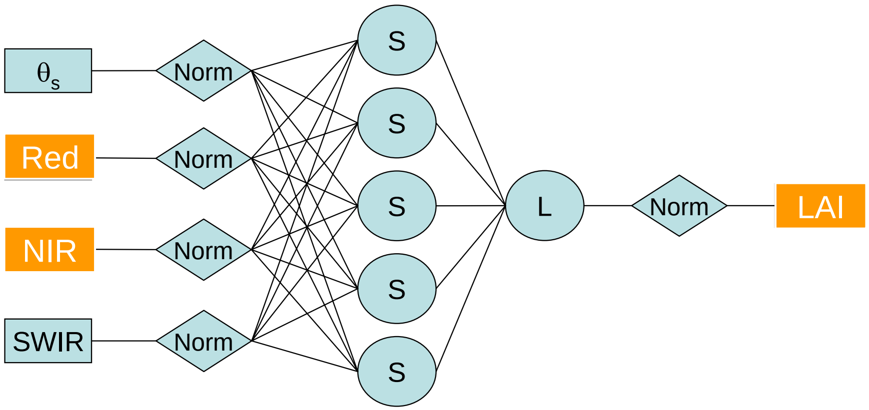
Consistency between original products



OK for reflectances
(biaises between 3 to 7 %)

Large scattering for LAI
due to products definition
Assumption on architecture
and algorithm principles

Neural network training process



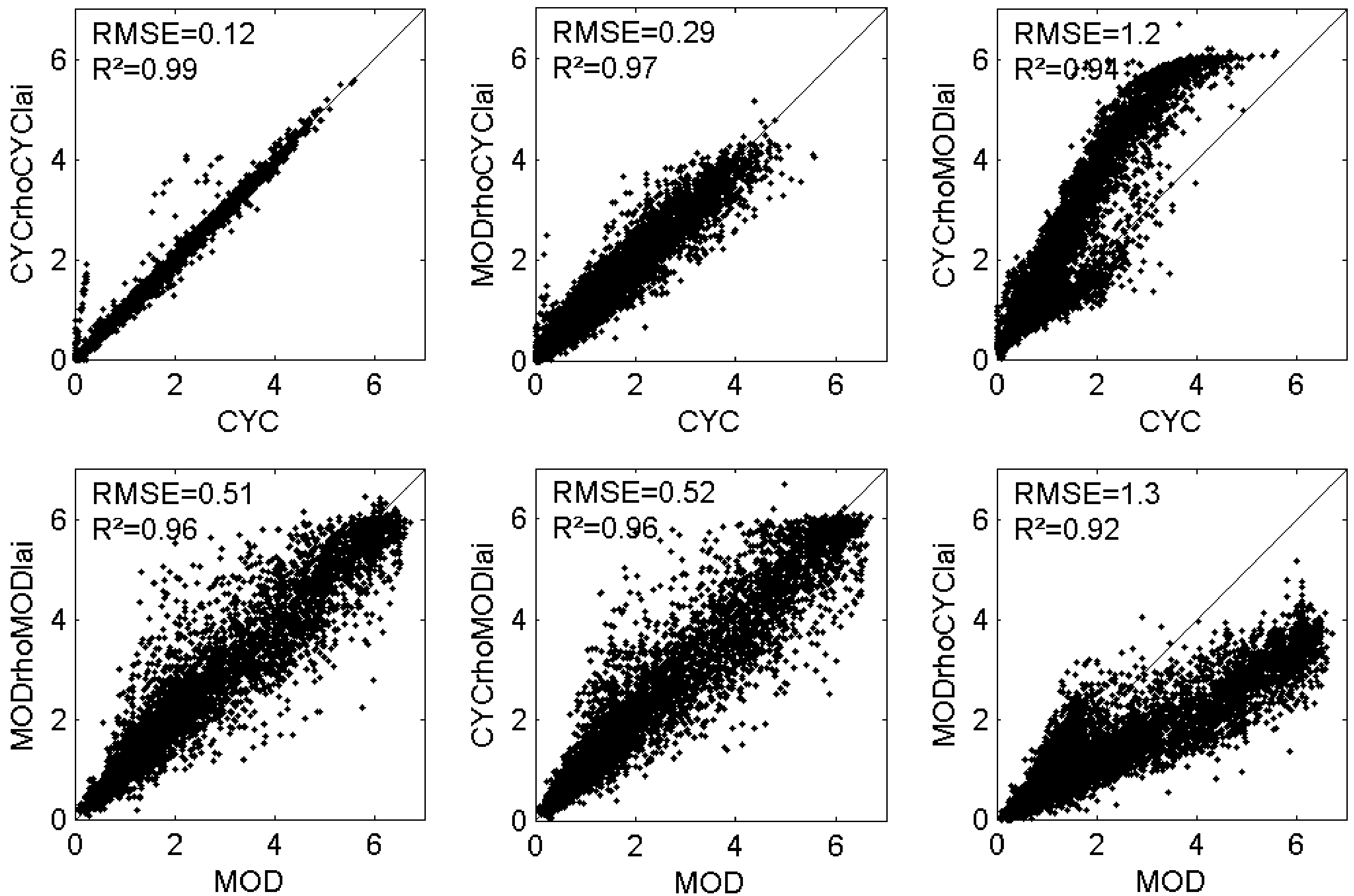
Four combinations investigated

	CYCLOPES reflectances	MODIS reflectances
CYCLOPES LAI	**CYCrhoCYClai** **0.119**[a] (0.129[b])	**MODrhoCYClai** **0.297** (0.305)
MODIS LAI	**CYCrhoMODlai** **0.525** (0.609)	**MODrhoMODlai** **0.502** (0.558)

[a]RMSE per vegetation class
[b]RMSE all vegetation classes

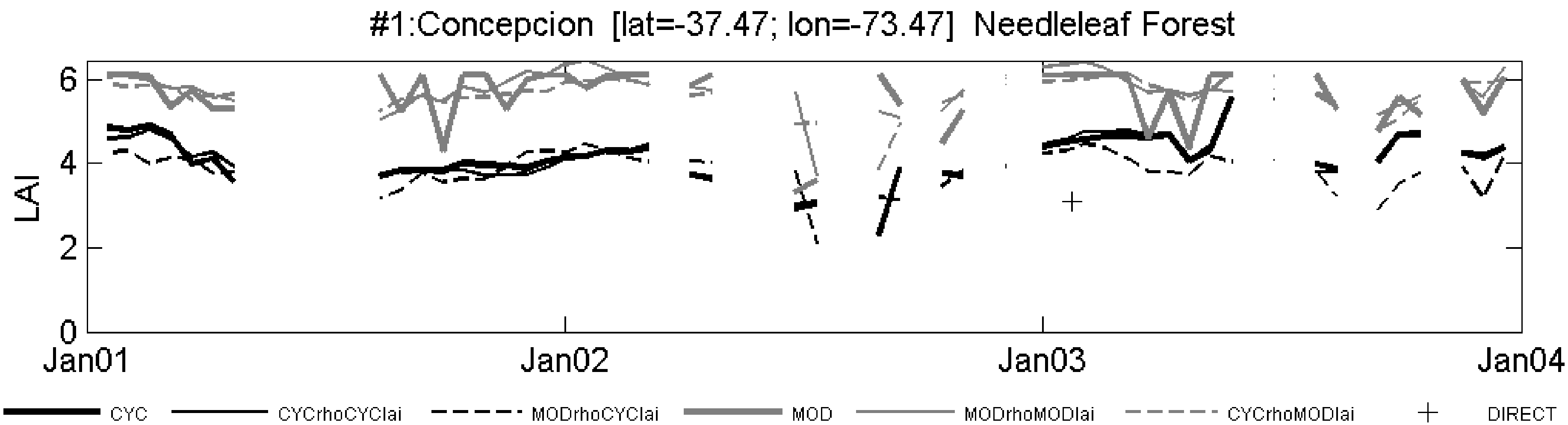
Good capacity of neural networks to 'learn' any algorithm

Satistical distribution across biomes

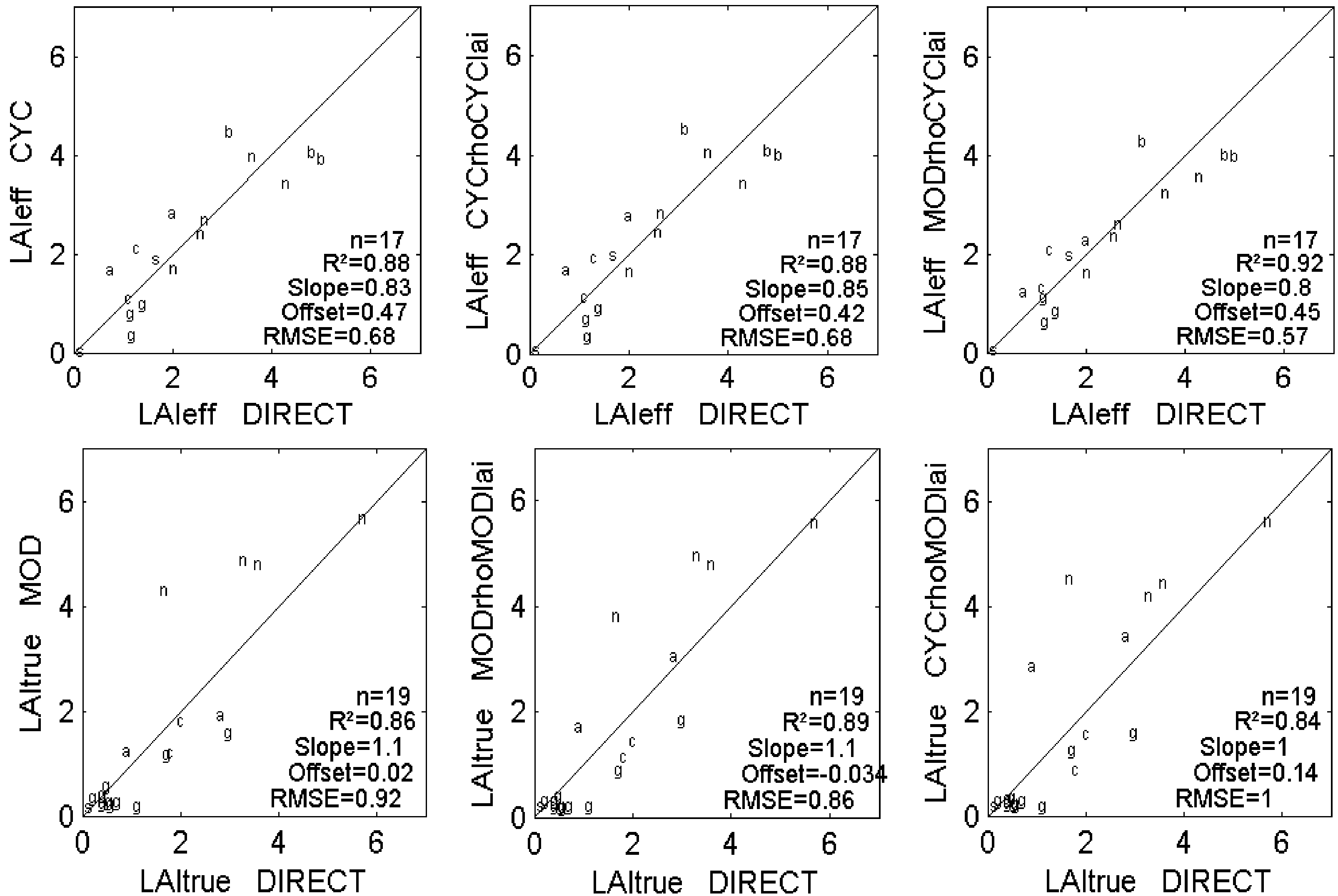


Good consistency when trained with same LAI but different reflectance source
Poor consistency between CYCLOPES and MODIS original LAI products values

Results: Temporal profiles



Direct Validation



Towards virtual constellation products: CONCLUSION

- Innovative approach allowing easy fusion of observations coming from several sensors
- Importance of the training data base (LAI)
- Applies to any product (even albedo!)
- No need for absolute reflectance calibration or strong spectral consistency between sensors: just temporal and spatial stability!
- Application over instantaneous observations (including or not atmosphere)
- Need good geometrical consistency
- First implementation in GEOLAND_2 project (EC) for Long Time Series (as opposed to Near Real Time)
- 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*, accepted for publication.

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-06-04	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. Strahler, 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 2006) 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. Strahler, 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-06-09	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-06-01	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-06-02	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. Strahler, Philippe Mayaux, LPV chair	1, 2, 3, 4
Ecosystems	EC-06-07	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. Strahler 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

Planed activities

- Future meeting
  - Albedo meeting AGU fall 2008
  - Soil moisture (SMOS) TBD
  - Temporal signature in remote sensing. January 2010??
- fAPAR products validation
- Continue collecting ground validation
- Test and exploit PAR@METER devices for continuous fAPAR/LAI monitoring
- Products PSF characterization
- On line validation (CALVAL portal)
- Populate calval portal (definitions, best practices)

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
  - Encourage agencies to prepare subsets of data/products for global product intercomparison activity as described by CEOS/WGCV/LPV
- Need more consistency in geometrical formats (grid/projection/datum)
- Need ressources for implementation of the 'on line validation tool' in the CAL/VAL portal