Quality Assessment and Continuous Quality Monitoring of Copernicus Global Land LAI/FAPAR ECVs products

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Outline

- Global Land Service
- Portfolio
- Validation strategy
- Quality Assessment
- Continuous Quality Monitoring
- Evolution
- Conclusion

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- **Global Land Service**
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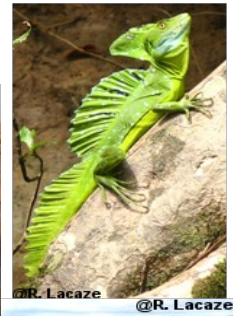
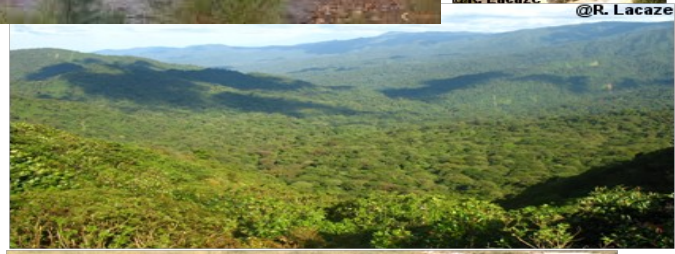
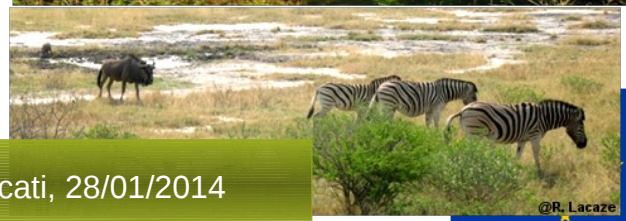
Global Land Service

- **Support and consolidate:**
  - EU contribution to GEO/GEOSS
  - EU policies at international level
    - e. g. Climate and Development policies
  - EU commitments under international treaties and conventions
    - e. g. UN “Rio” conventions: UNFCCC, UNCCD, UNCBD
- **EU Policy focus:**
  - Crop Monitoring and Food security
  - Biodiversity, Protected areas and Forest cover monitoring
  - Drought Assessment and Desertification
  - Carbon modeling, land use and land cover change
  - Support to Earth Observation African Activities



Global Land Service

- **A global systematic monitoring service**
  - **Production**
  - Bio-geophysical variables over the globe
  - NRT delivery (hourly -> 10-days)
  - consistent historical SPOT/VGT time series (15+ years)
  - **Quality control**
  - Technical quality
  - Scientific quality (i.e. Validation)
  - Service quality
  - External audits
  - **Archiving & re-processing**
  - **Dissemination & user support**

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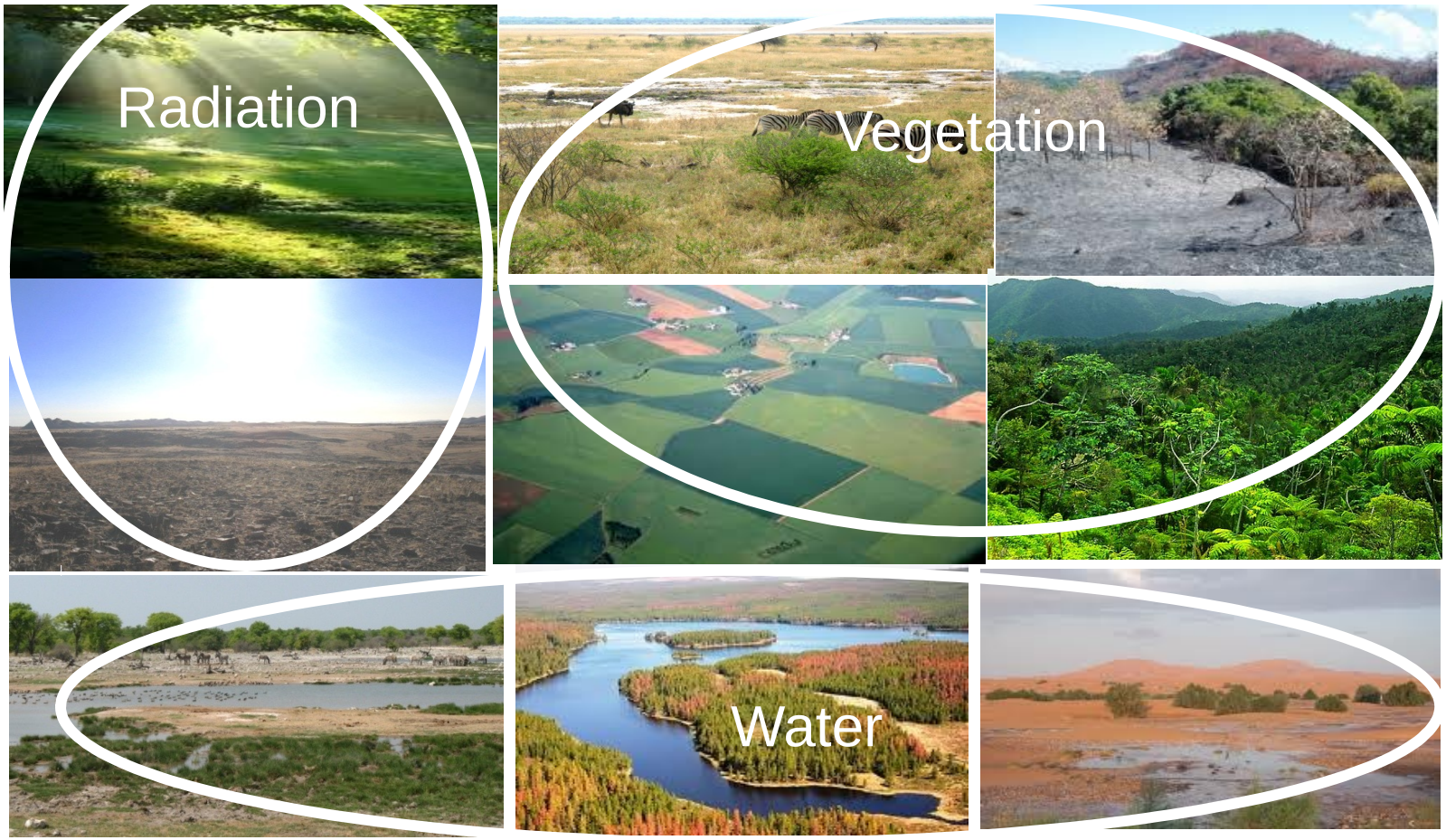
Portfolio



Portfolio

Variable	Temporal Coverage	Temporal resolution	Spatial coverage	Spatial resolution	Sensor	Timeliness
LAI/FAPAR/FCover	1999 – present	10 days	Global	1km	SPOT/VGT	3 days
NDVI/VCI/VPI	1999 – present	10 days	Global	1km	SPOT/VGT	3 days
Dry Matter Productivity	2009 – present	10 days	Global	1km	SPOT/VGT	3 days
Burnt Area	1999 – present	1 day	Global	1km	SPOT/VGT	3 days
TOC Reflectance	2013 – present	10 days	Global	1km	SPOT/VGT	3 days
Surface Albedo	1999 – present	10 days	Global	1km	SPOT/VGT	3 days
Land Surface Temperature	2009 – present	1 hour	Global	0.05°	Σ Geo	1 day
Soil Water Index	2007 – present	1 day	Global	0.1°	Metop / ASCAT	1 day

* Currently Africa only

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Scientific Quality Control

- **Per variable: following the guidelines, protocols and metrics defined by the Land Product Validation group of CEOS.**
  - **Quality Assessment** aims to assess the uncertainty attached to the products by performing an exhaustive scientific validation.

    Validation of new products before operational production (2 years of test data)

  - Continuous **Quality Monitoring**: aims to assess if the recent GIO-GL products keep the same level of quality than the fully validated products (i.e. if quality is preserved along time)

    Lighten procedure over global networks of sites (every 6 months)

- **Cross-cutting check: consistency across variables using a Land Data Assimilation System**
  - Assimilation of LAI, SWI and surface Albedo → Simulated FAPAR and LST are compared to satellite products)

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Applicable requirements

- **LAI**
  - GCOS
    - Accuracy: Max(20%,0.5) & Stability: Max(10%,0.25)
  - GEOLAND-2 BIOPAR Users
    - Optimal: 10%
    - Target: 15%
    - Threshold: 25%
  - Uncertainties attached to ground data larger than LAI requirements !

- **FAPAR**
  - GCOS
    - Accuracy: Max(10%,0.05) & Stability: Max(3%,0.02)
  - GEOLAND-2 BIOPAR Users
    - Optimal: 0.05
    - Target: 0.1
    - Threshold: 0.15

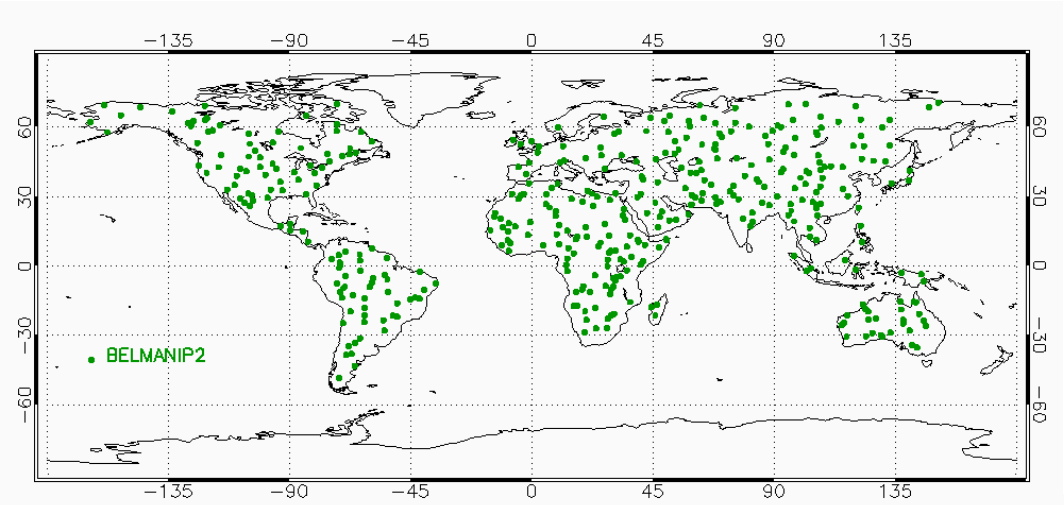
- **Additional requirements from Geoland-2/BioPar users:**
  - Product Continuity
  - Temporal Consistency
  - Precision and Smoothness
  - Reliable magnitudes over well know areas

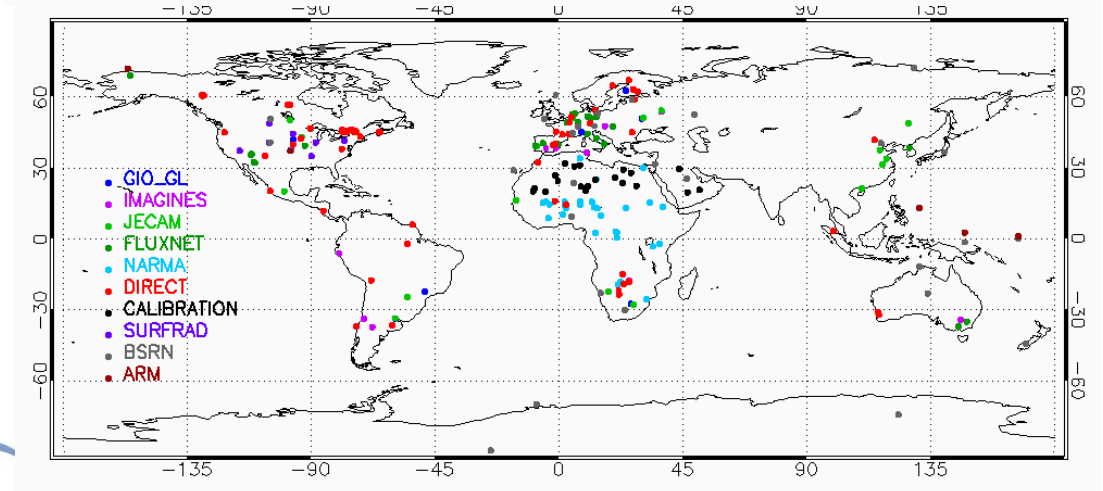
Quality Assessment: Procedure

- Validation protocol (best-practices):
- Direct Validation (Accuracy)
- Indirect evaluation (Inter-comparisons)
- Quality checks

Criteria	Metrics
Spatial Consistency	➢Maps of the products ➢Difference maps (mean bias) with reference products
Product Continuity	➢Fraction of missing data (gaps) ➢ Length of gaps
Global Statistical Analysis	➢ Histograms and Scatter-plots (R2, RMSE, Bias, Scattering) per biomes over BELMANIP-2 network of sites
Temporal Consistency	➢Temporal profiles over BELMANIP-2+ DIRECT sites
Smoothness	➢ Histograms of the short time stability
Accuracy	➢ Direct comparison with reference maps
Quality checks	➢ Error bars, Quality Flags ➢Magnitude over well-know areas
Regional Assessment	➢ Spatial Consistency (Difference maps) ➢ Scatter-plots and metrics per main biome over regions

QA: Procedure





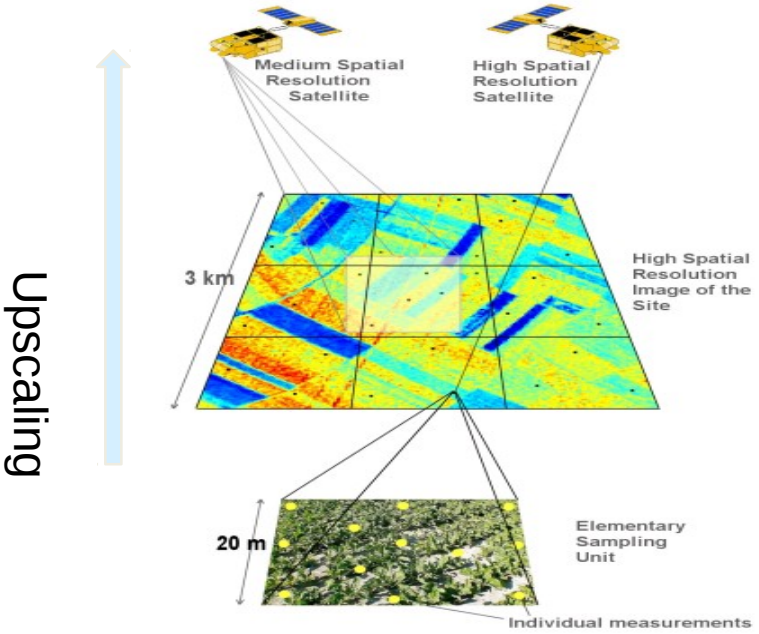
445 BELMANIP2.1 sites

+

240 additional sites

Temporal profiles are analyzed over 685 sites

QA: Ground dataset



Know limitations:

- Limited sampling, not well distributed
- Clumping is a main uncertainty for the LAI maps
- Optical measurements (LAI2000, TRAC) do not distinguish 'green' from 'brown' elements
- Understory sometimes not measured → Discarded for QA.
- Inadequate spatial sampling, saturation of the signal, algorithm principles (eg., black leaves for FAPAR)…
- Need to better characterize uncertainties of reference maps !

- **Garrigues et al (2008)** collected 81 LAI reference maps, over homogeneous sites, tipically of 3x3 km2, coming from intenational initiatives such as VALERI, BigFoot, Boston University, CCRS, USEPA, etc
- Additional maps from ground data coming from ESA, MODLAND and other actitivities were added (**Camacho et al. 2013**)
- Available CEOS cal/val portal: **OLIVE DIRECT sites**

QA: Reference Products

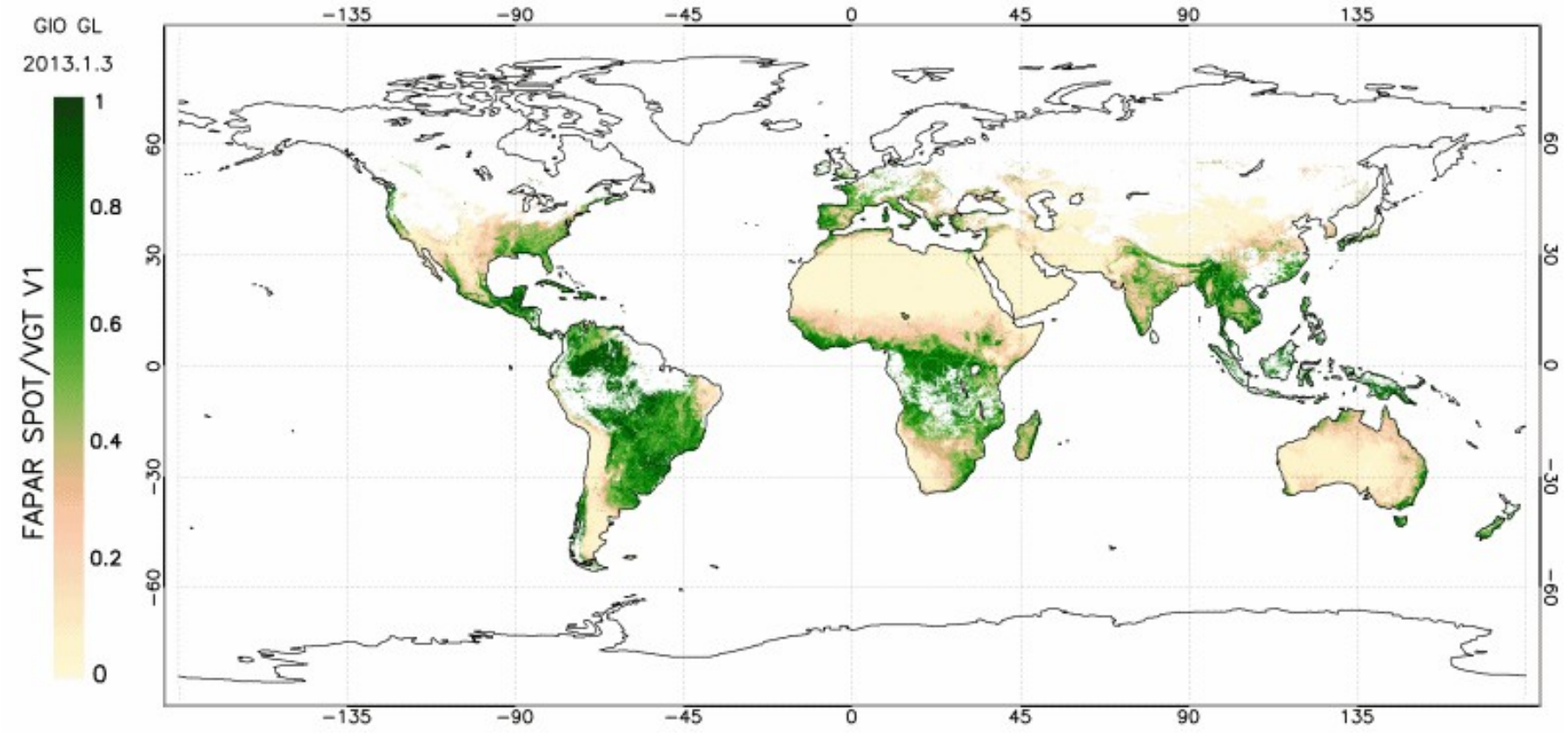
PRODUCTS	GEOv1 (LAI, FAPAR, FCOVER)	REFERENCE PRODUCTS			
		CYCV31 = GEOV0	GLOBV2	JRC SeaWIFS	MOD15A2-C5
Sensor/ Plataform	VEGETATION /GT			SeaWiFS Orbview-2	MODIS/ TERRA
Spatial Resolution	1 km	1 km	1 km	2.71 km	1 km
Temporal frequency	10-days	10-days	monthly	daily	8-days
Temporal Window Product Date	30-days (+17)	30-days (+15)	30-days (+10)	1-day	16-days
Proyection	Plate carrée	Plate carré	Plate carré	Sinusoidal	Sinusoidal

Same spatial support (Plate Carré, 3x3 km) and temporal support (monthly) were considered for intercomparisons

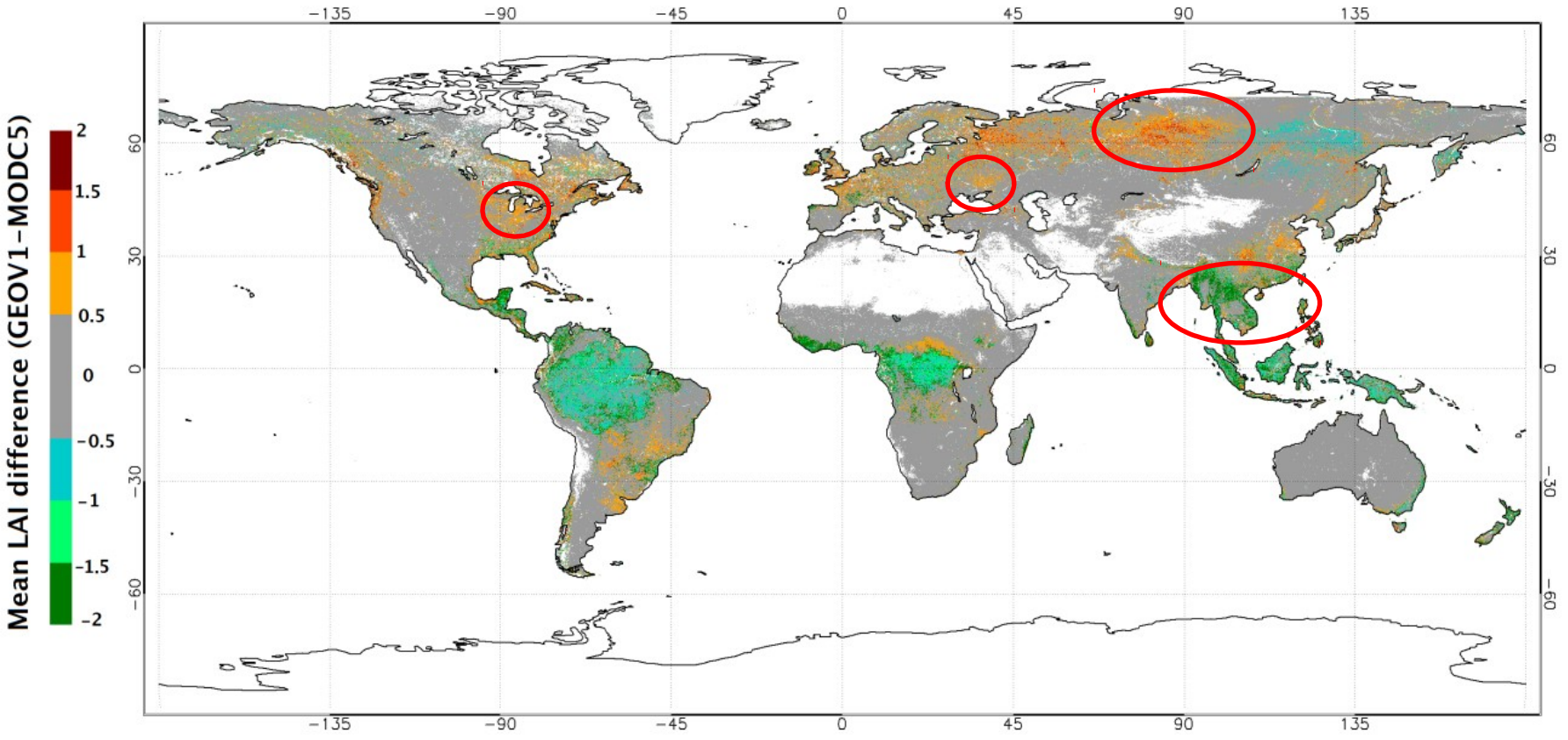
QA: Spatial Consistency

Sensor	SPOT/VGT
Resolution	1/112°
Frequency	10 days
Period	1999 – NRT
Target accuracy	0.05 GCOS 0.1 BioPar

GEOV1 FAPAR



QA: Spatial Consistency



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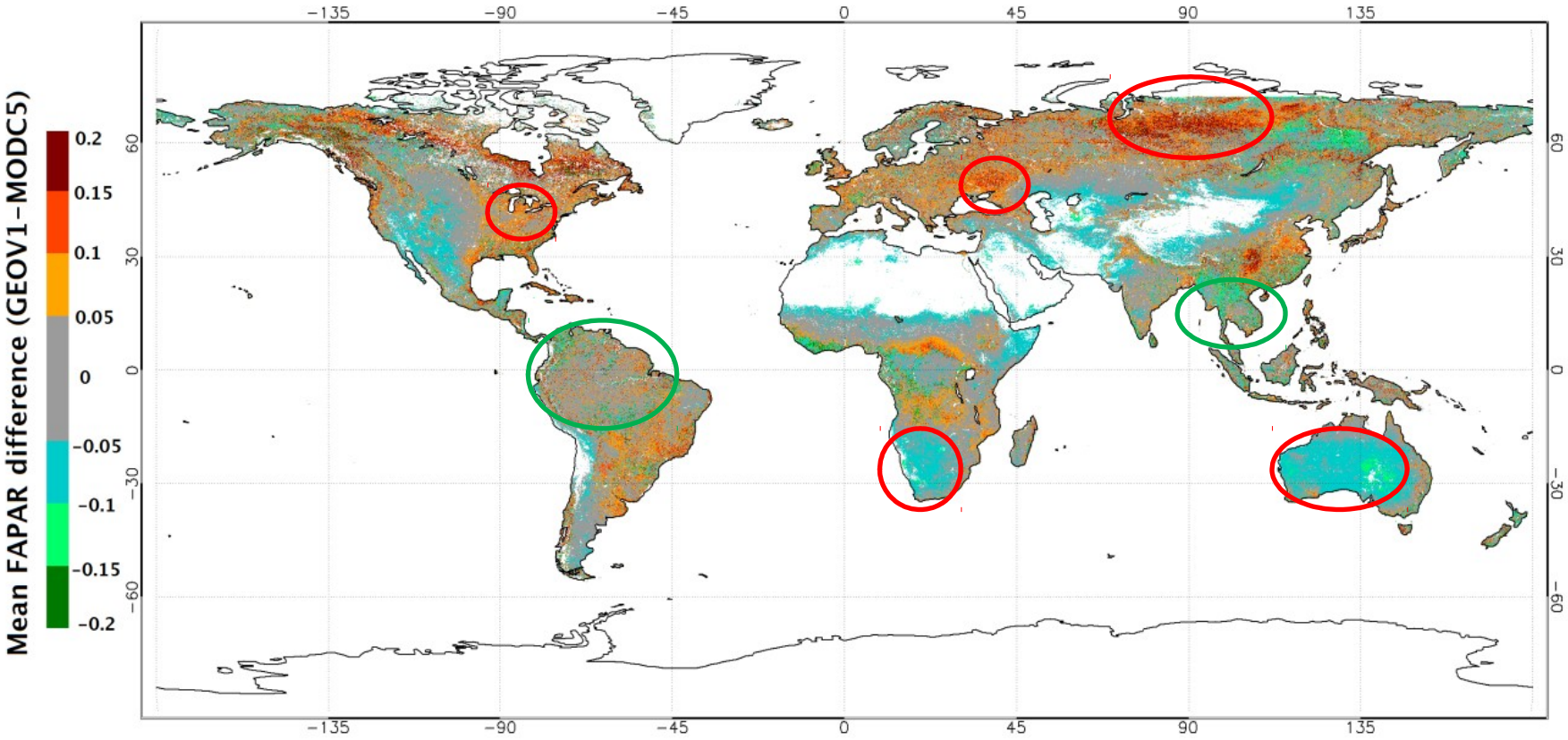
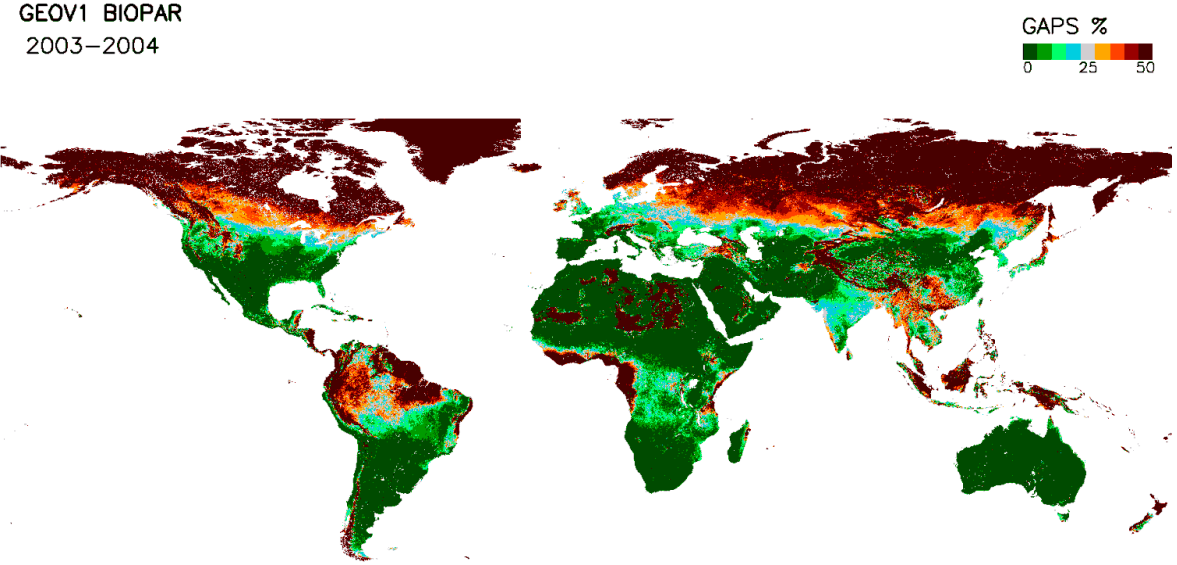
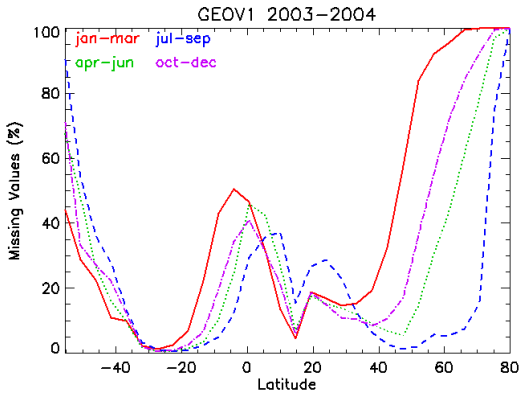


QA: Product Continuity

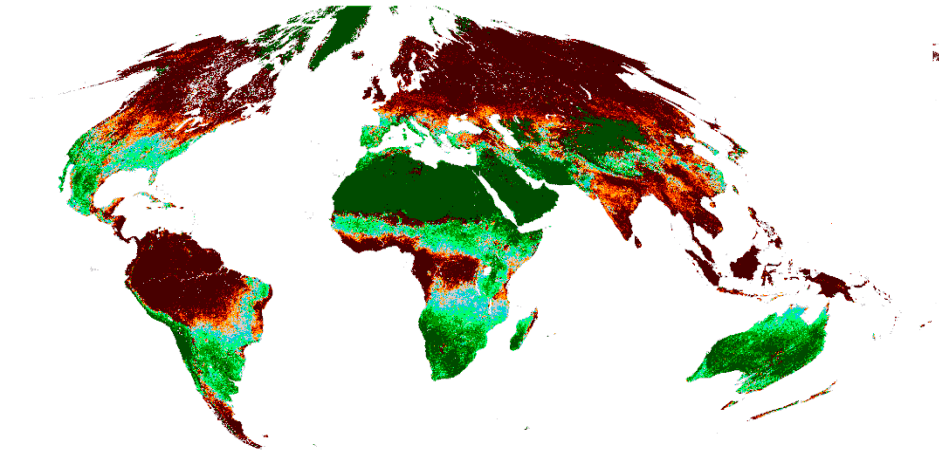
GEOV1 BIOPAR
2003–2004



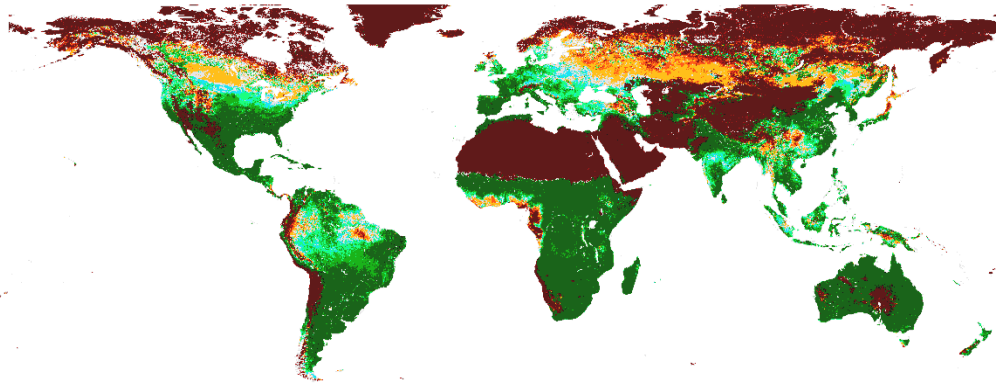
Missing Values



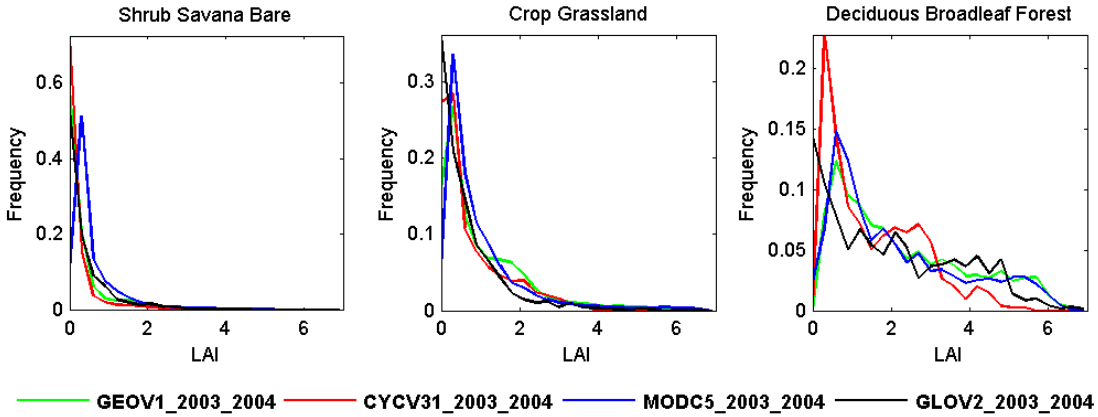
MOD15A2 MAIN
2003–2004

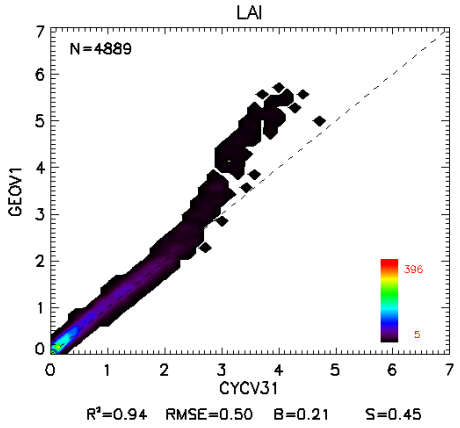


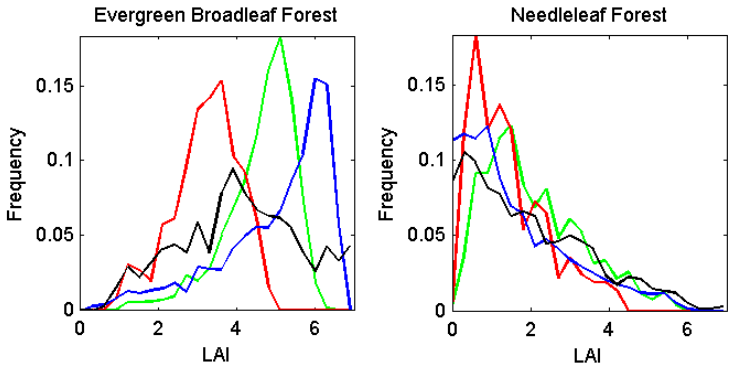
GLOBCARBON v2
2003–2004

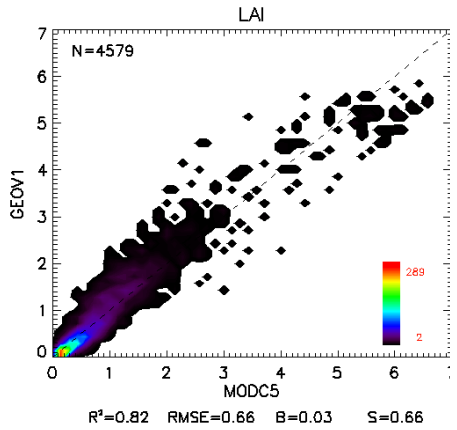


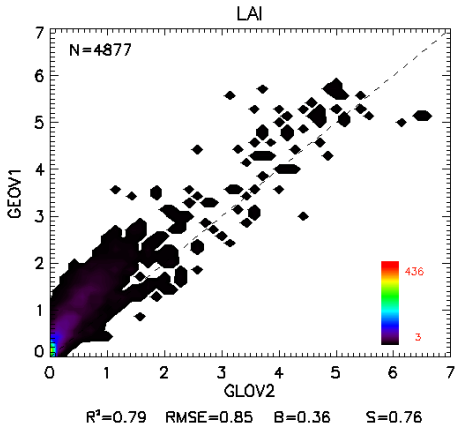
QA: Global statistical analysis











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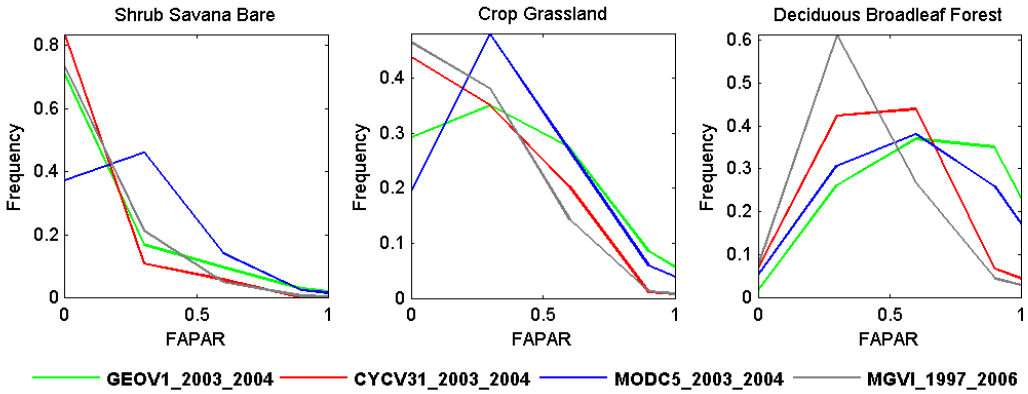
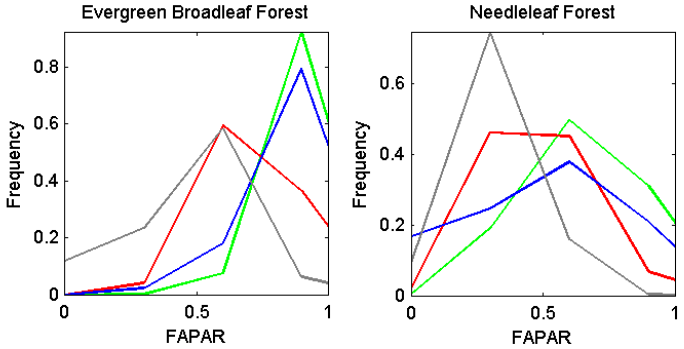
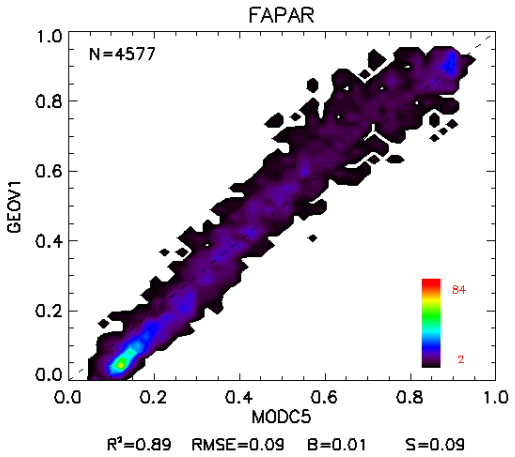
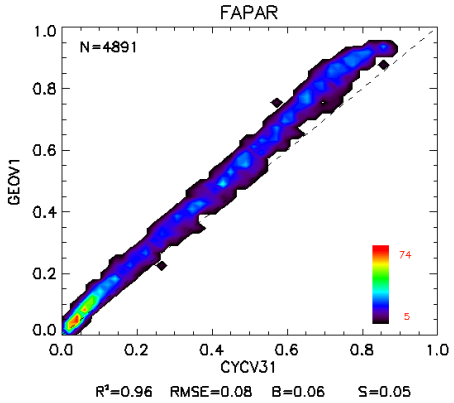
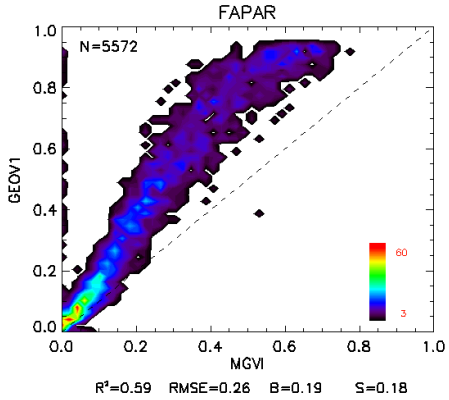


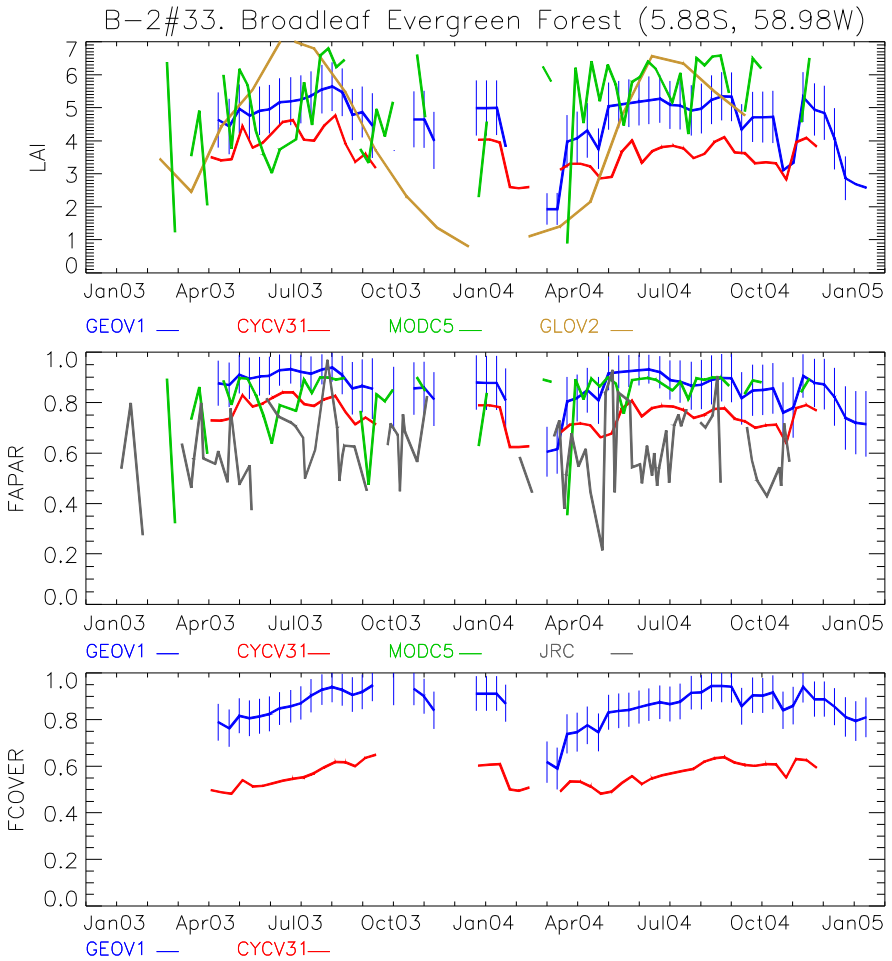


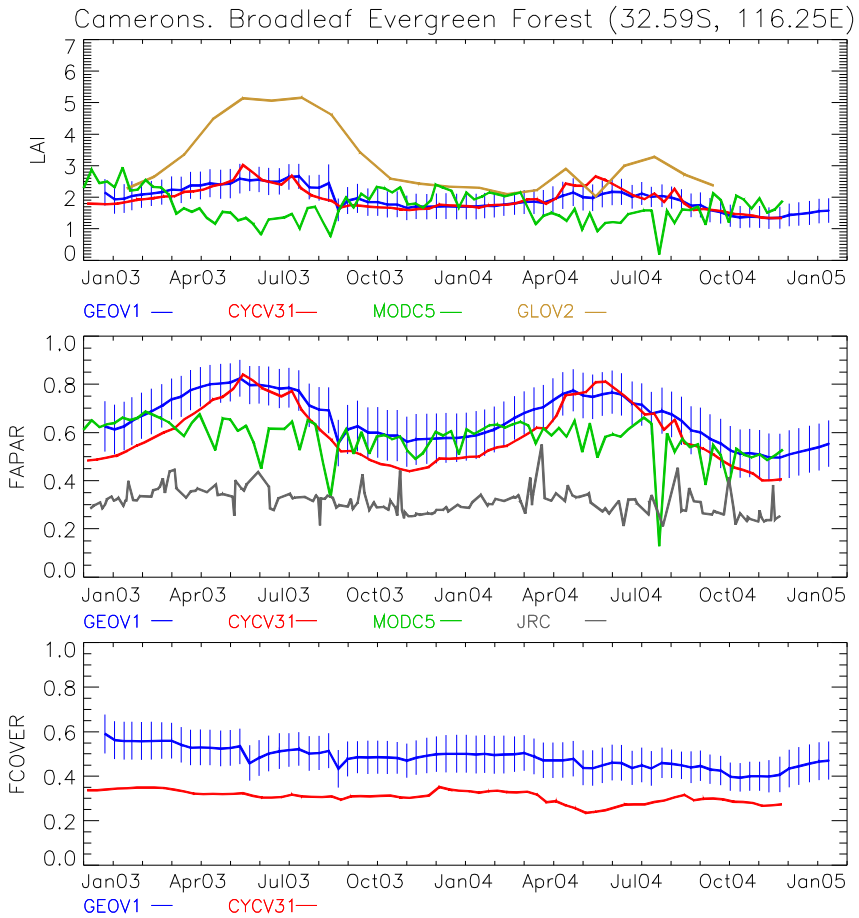






QA: Temporal Consistency





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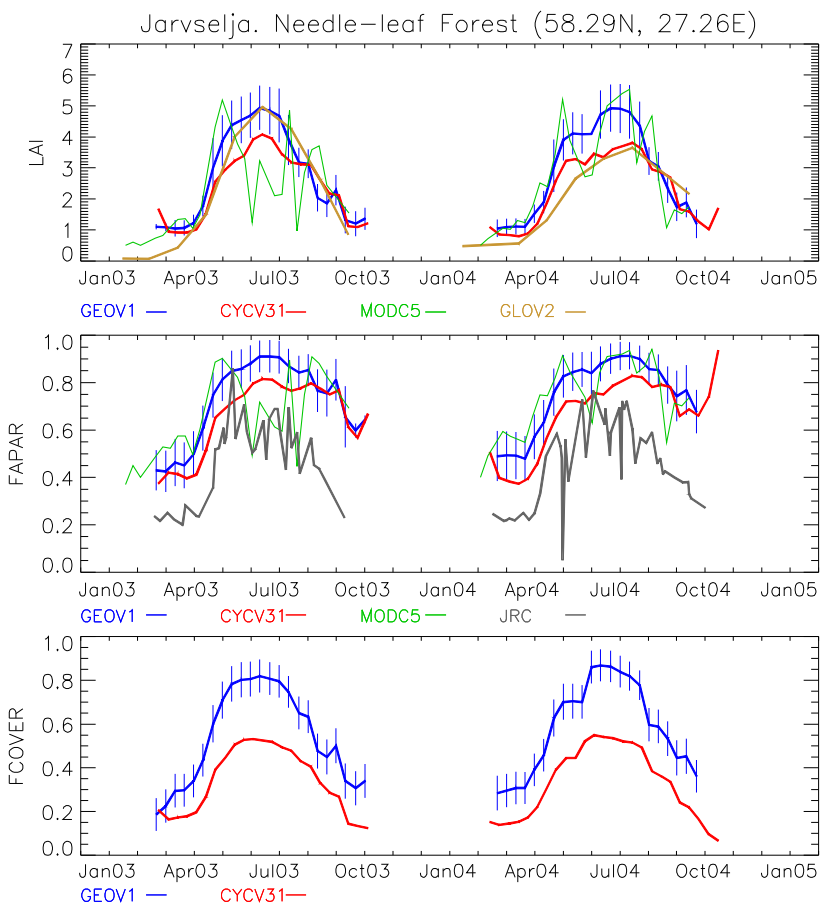

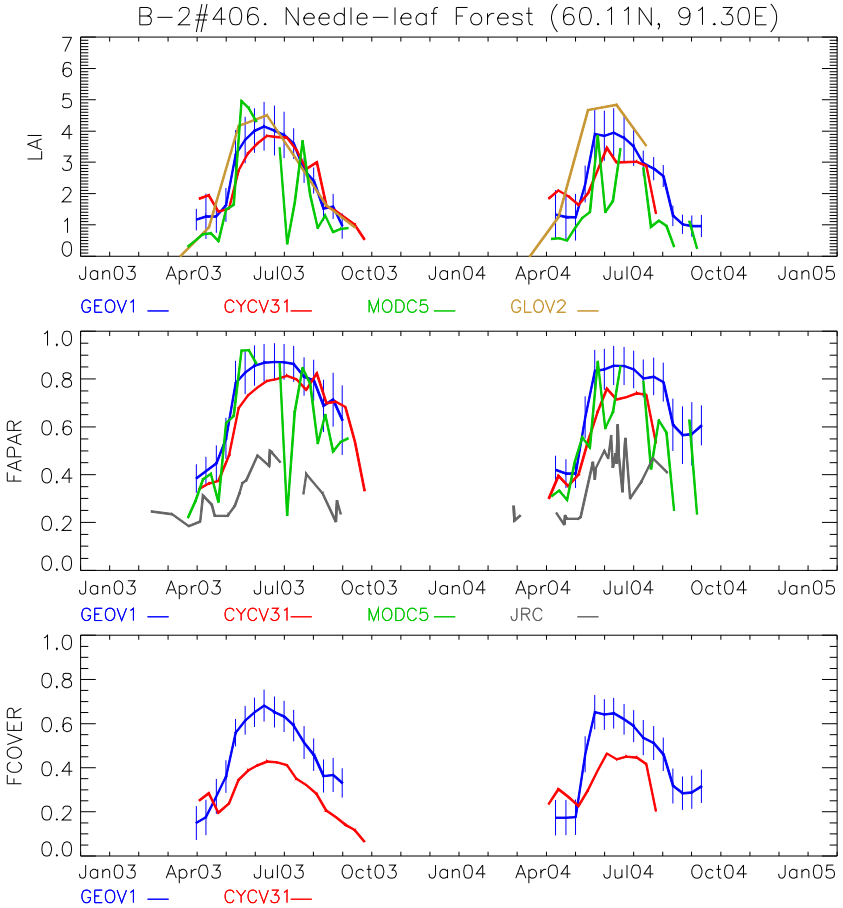

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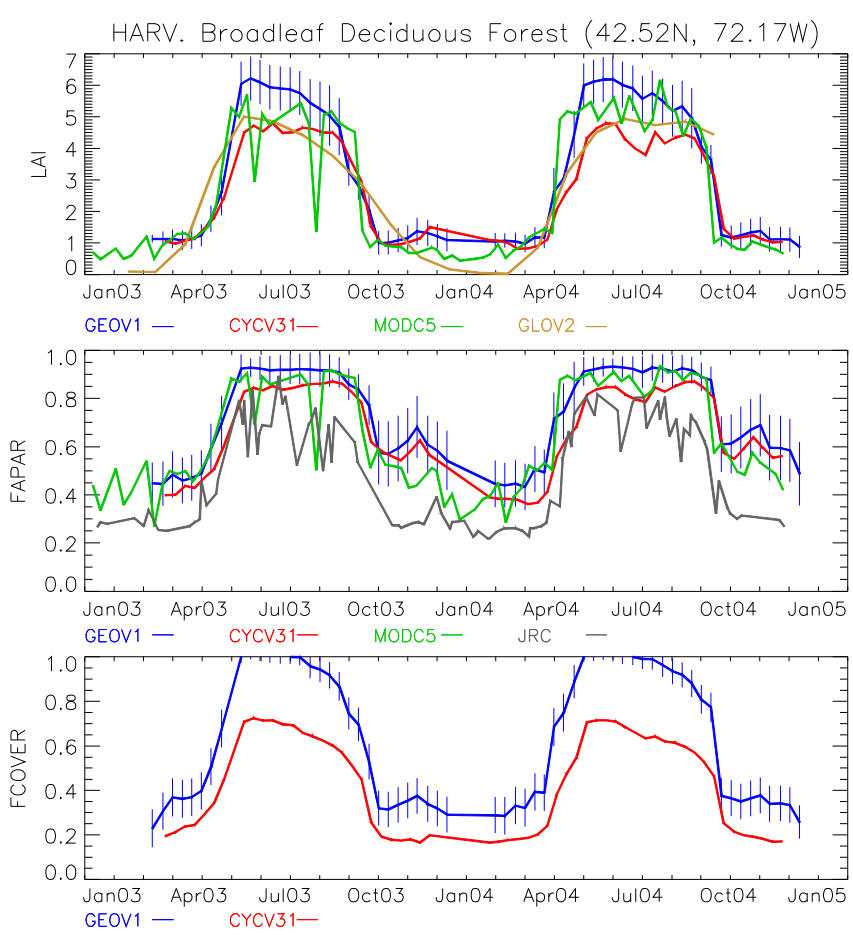

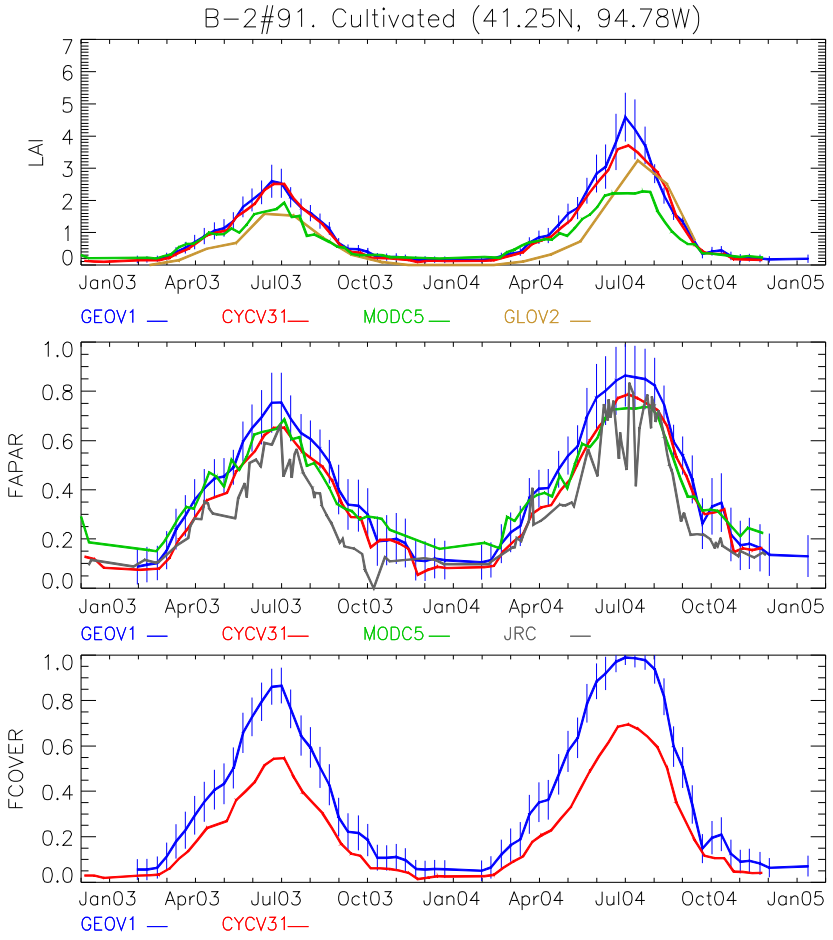

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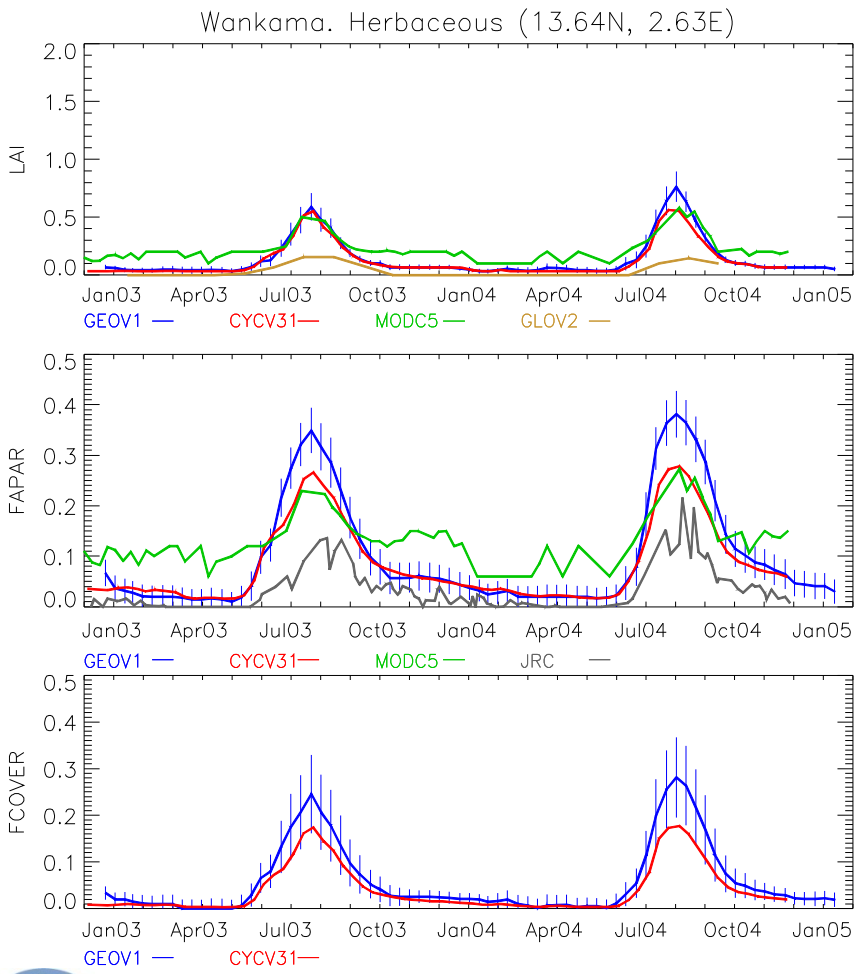
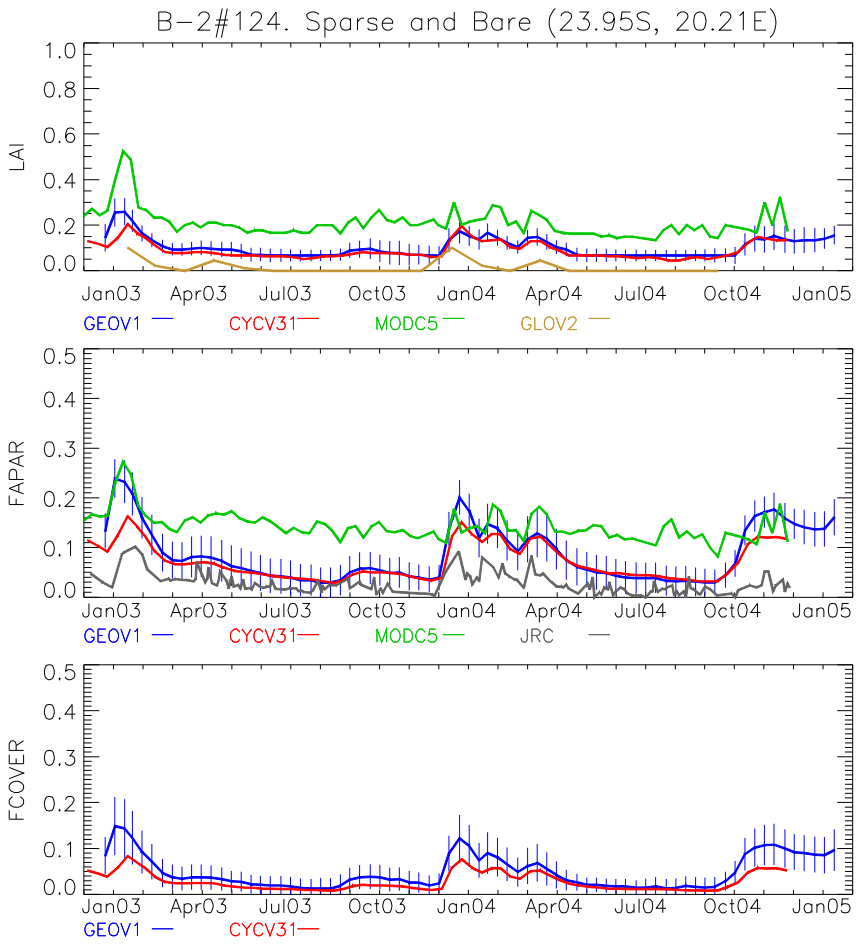
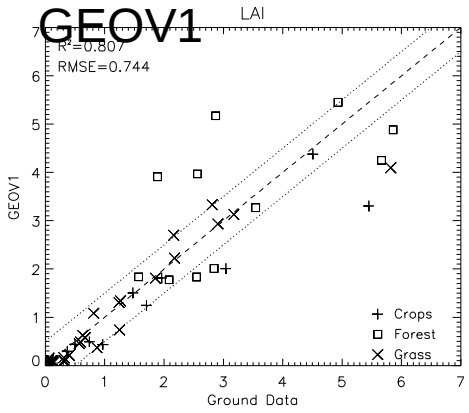


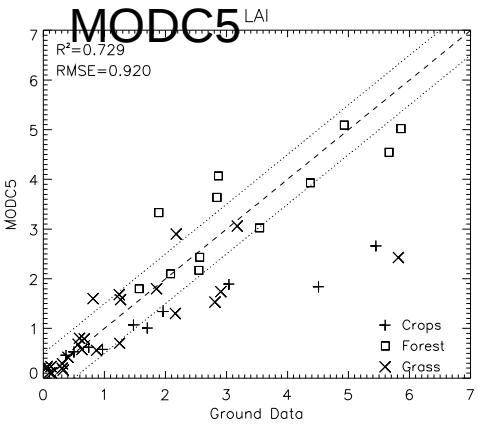


QA: Accuracy Assessment

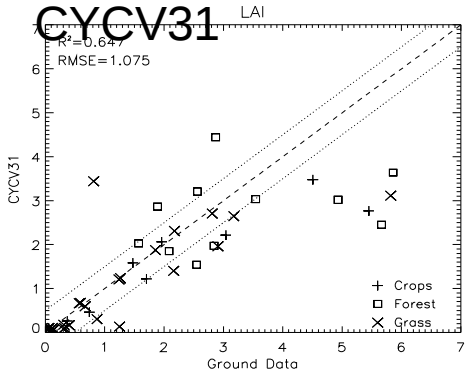
GEOV1



MODC5

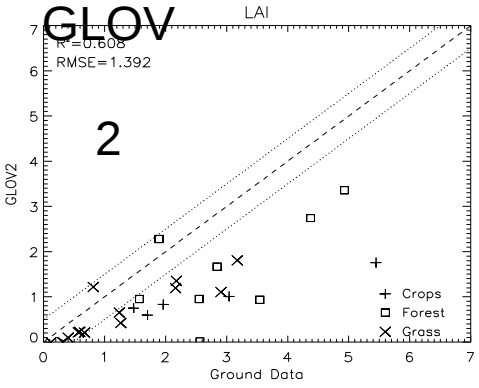


CYCV31



GLOV

2

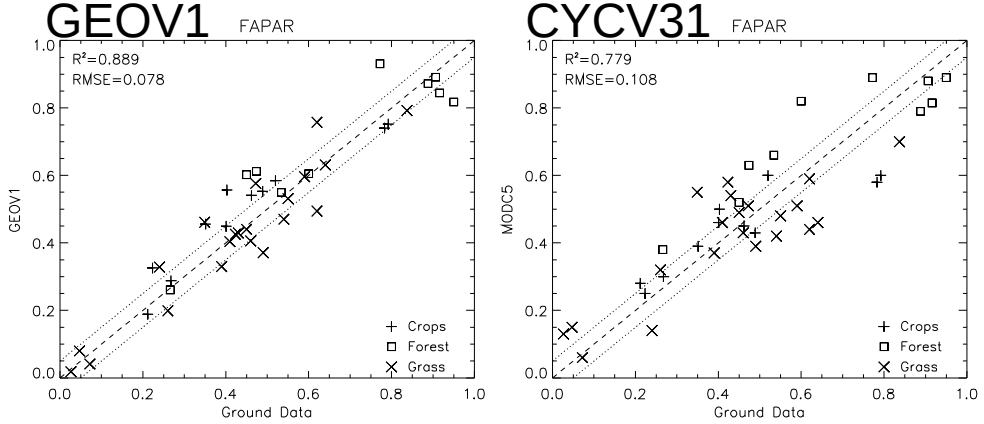


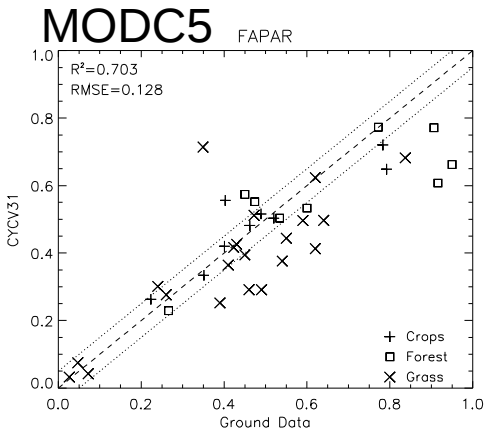
LAI

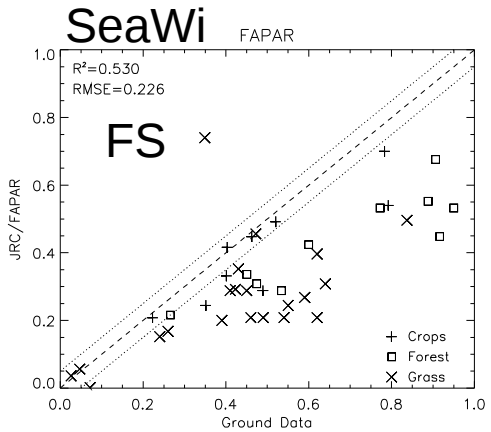
CYCV3

	GEOV1	1	MODC5	GLOV2
N	48	45	49	27
RMSE	**0,74**	1,07	0,92	1,39
B	**-0,10**	-0,36	-0,26	-1,05
S	**0,737**	1,01	0,88	0,92
R2	**0,807**	0,647	0,729	0,608
Slope	**0,85**	0,59	0,69	0,46
Offset	0,15	0,41	0,31	**0,02**

QA: Accuracy Assessment







	FAPAR			
	GEOV1	CYCV31	MODC5	SeaWiFS
N	42	39	42	40
RMSE	**0,08**	0,13	0,11	0,23
B	0,014	-0,04	**0,006**	-0,16
S	**0,08**	0,12	0,11	0,16
R2	**0,889**	0,707	0,779	0,53
Slope	**0,91**	0,69	0,77	0,54
Offset	**0,05**	0,45	0,11	0,06

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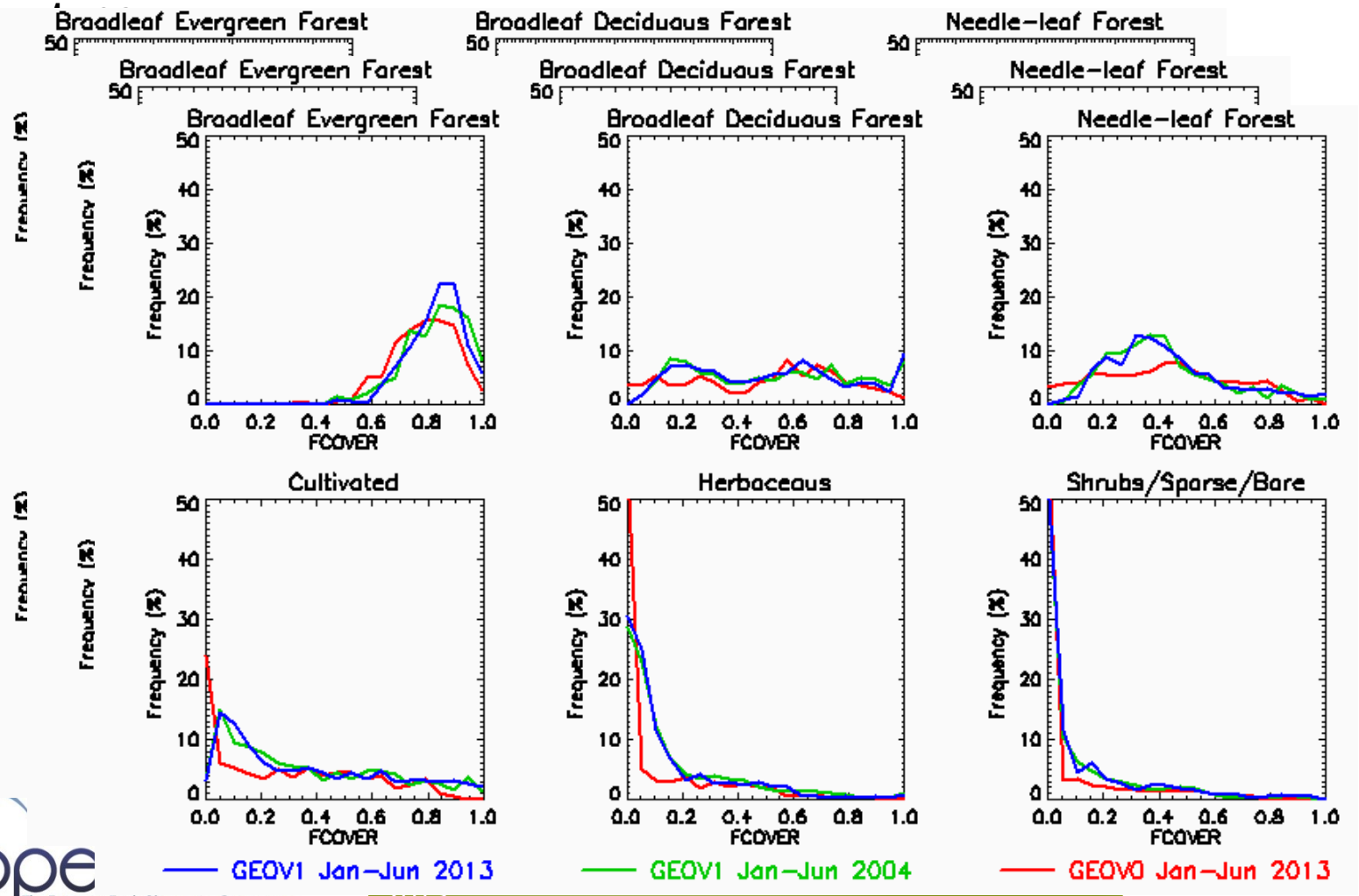
Quality Monitoring: Procedure

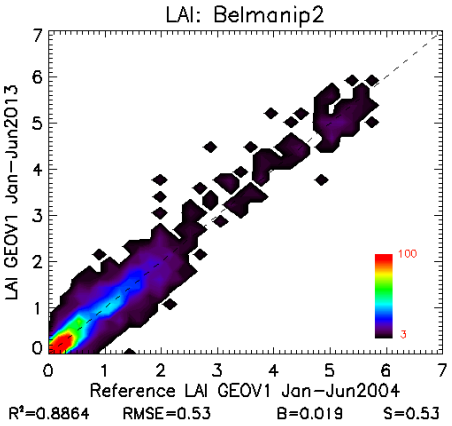
Criteria	Recent Product (2013)	Reference Products	Coverage
Spatial Consistency	GEOV1 GEOV0	Validated GEOV1	Global
	Maps of the products and difference maps with reference products		
Product Continuity	GEOV1	Validated GEOV1	Global
	Fraction of missing data (gaps), Length of gaps		
Global Statistical Analysis	GEOV1 GEOV0	Validated GEOV1	420 BELMANIP2 sites
	Histograms and Scatter-plots (R2, RMSE, Bias, Scattering) per biomes		
Temporal Consistency	GEOV1 GEOV0	LSA SAF MODIS C5	420 BELMANIP2 sites + 266 additional sites
	Temporal profiles over 686 sites were analyzed		
Smoothness	GEOV1	Validated GEOV1	420 BELMANIP2 sites
	Histograms of the short time stability		
Regional Assessment	GEOV1 GEOV0	LSA SAF	Africa 80ºx80º
	Difference maps, scatter-plots and metrics per main biome		

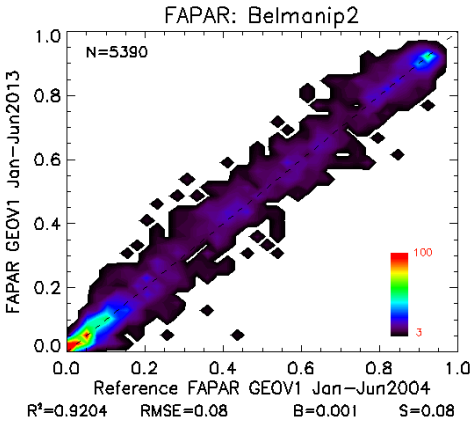
Quality Monitoring: Global statistics

Distribution of retrievals per Biome

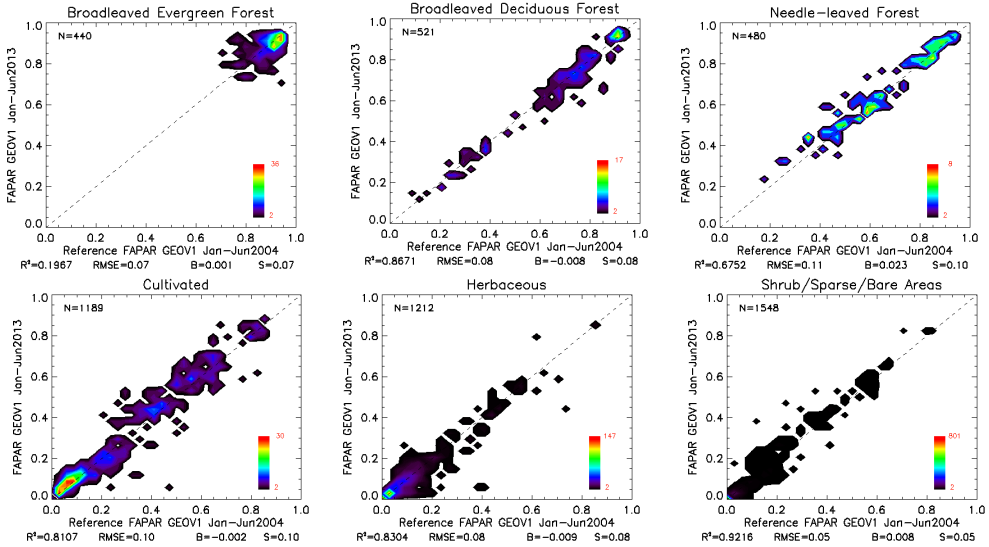


Quality Monitoring: Global statistics





- No Bias
- RMSE better than the uncertainty attached to validated products

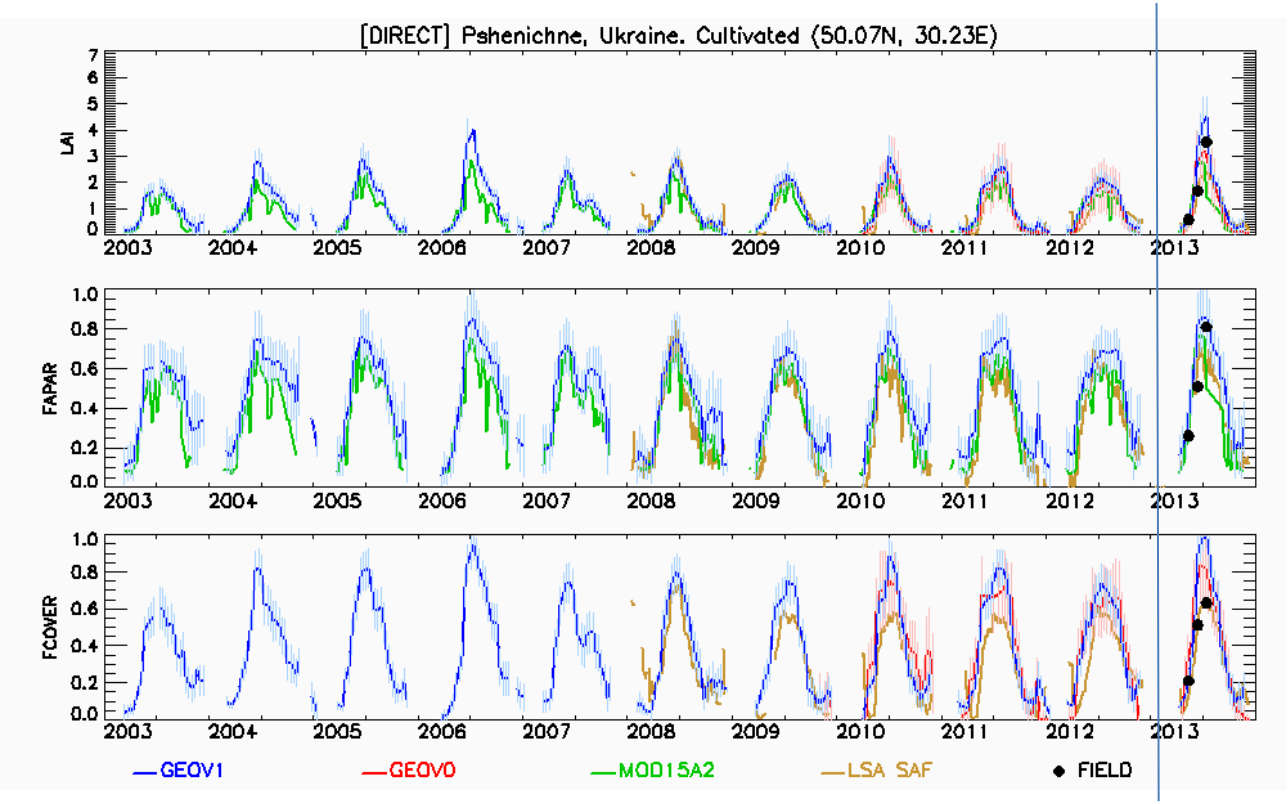


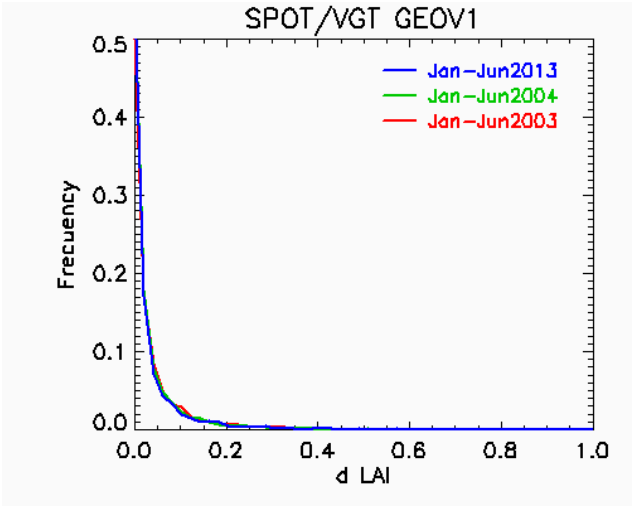
Scatter Plots p biomes where analysed

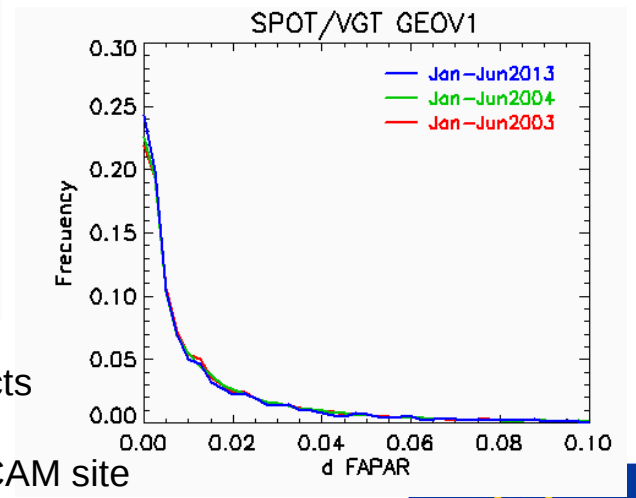
QM: Temporal Consistency

Temporal Consistency Analysis

Temporal Smoothnes:





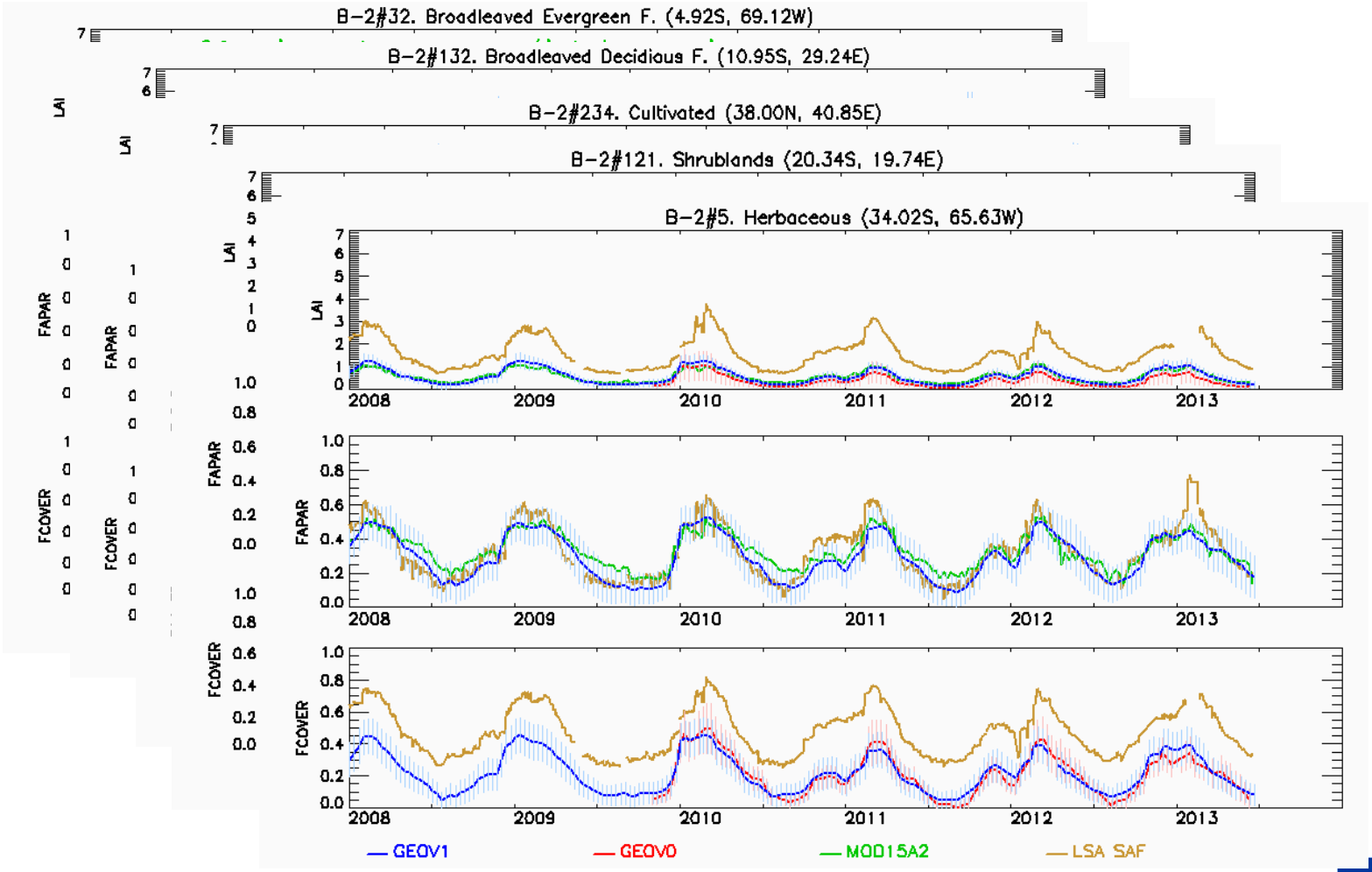


Recent Products

Ground data thanks to Ukranian JECAM site

QM: Temporal Consistency

Temporal Consistency Analysis

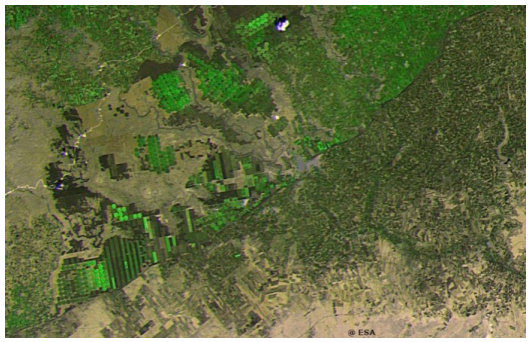


Outline

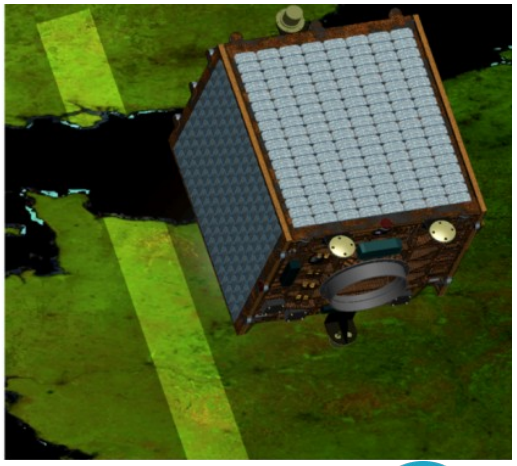
- Global Land Service
- Portfolio
- Scientific Quality Control
- Quality Assessment
- Continuous Quality Monitoring
- **Evolution**
- Conclusion

Evolution: *300m products*

- **Moving from 1km to 300m resolution products**
  - PROBA-V ensures continuity between SPOT/VGT & Sentinel-3
  - Successfully launched on 6th May
  - 6 months of commissioning (Nov 2013)



Proba-V 300m image acquired over Turkey-Syria on 28th May 2013



- **Objective: pre-operational NRT products starting on May 2014 over Europe**
  - Using the achievements of the FP7 ImagineS project

Evolution: Validation

- **Validation over a network of demonstration sites**
  - In collaboration with local users
  - For ground data acquisitions and users evaluation
  - Set-up of PASTIS-PAR sensors for continuous monitoring of PAI/FAPAR

ID	Name
1	South-West, France
2	Hegyhatsal, Hungary
3	Las tiesas Farm, Barrax, Spain
4	Córdoba, Spain
5	Cartagena, Spain
6	Tula, Russia
7	Pandamatenga, Bostwana
8	Merguellil, Tunisia
9	Free State Province, South Africa
10	Greenbelt Farm, Ottawa, Canada
11	Lambayeque, Peru
12	Requínoa, VI Region of Chile, Chile
13	25 de Mayo, La Pampa, Argentina
14	Yanco area, Murrumbidgee River catchment, Australia

Outline

- Global Land Service
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- Quality Assessment
- Continuous Quality Monitoring
- Evolution
- **Conclusion**

Conclusions

Criteria	Performance	Comments
Spatial Consistency	+	➢Good spatial consistency ➢Differences between products for some regions
Product Continuity	-	➢Main limitations over Northern latitudes in wintertime and Equatorial areas.
Statistical Analysis	+	➢Distributions are very consistent. Larger discrepancies for Broadleaf Evergreen Forests and Needleleaf forest.
Temporal Consistency	+	➢Very reliable seasonal and inter-annual variations.
Smoothness	+	➢The temporal profiles are very smooth (better than 0.2 for LAI and better than 0.01 for FAPAR)
Precission	+	➢No Bias detected between validated and recent products ➢RMSE within the uncertainty of products
Accuracy	±	➢Not too far from GCOS accuracy goal (0.5, 0.05) ➢Target accuracy as required in Geoland2 for FAPAR
Quality Checks	+	➢Reliable magnitude for low and high values ➢Realistic error estimates

	GEOV1	MODIS	CYCLOPES	GLOBCARBON	SeaWiFS
Continuity (Missing Values)	-	-	-	-	
Magnitude High Values	+	+	-	+	-
Magnitude Low Values	+	-	+	+	+
Temporal Consistency (Precision)	+	+	+	-	+
Direct Validation (Accuracy)	+	+	+	-	-
Smoothness	+	-	+	monthly (+)	daily (-)

Copernicus
The European Earth Observation Programme

Concluding remarks

- **Copernicus Global Land service**
  - Started in 2013, provides sustainable delivery of NRT global products
  - Scientific Quality Control follows CEOS LPV best practices (when exists)
  - Quality Assessment (exhaustive validation)
  - Continuos Quality Monitoring (evaluation as the time serie expands)
- **Quality Assessment SPOT/VGT GEOV1**
  - Good results: better performances than reference products in many of the criteria evaluated
  - Very important discrepancies in term of magnitude between examined products (e.g. up to 100% in FAPAR)
  - Validated Stage 2 – Camacho et al., (2013). RSE
  - SPOT/VGT GEOV2 NRT and historic products (gap filling) ready for validation
- **Quality Monitoring SPOT/VGT GEOV1**
  - Effective to evaluate that recent products keep the QA level
- **Evolution (FP7 ImagineS)**
  - PROBA-V 300 m first products expected for May 2014
  - Multi-sensor products with the on-coming Sentinel-3, -2.
- **Validation Needs**
  - Continuous Ground data provision over network of sites is **essential** for validation of products (to reach Stage 3 and 4)
  - Collaboration with local users is **desirable** for better assess the product quality

Contact

Global Land consortium

vito vision on technology

HYGEOS

ipma

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ZAMG Zentralanstalt für Meteorologie und Geodynamik

EOLAB

INRA Institut National de la Recherche Agronomique

CREAF

UCL Université catholique de Louvain

University of Leicester

TU VIENNA

http://land.copernicus.eu/global

Thank You !

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EOLAB