Global Land Service

Consistency across missions of long time series of global biophysical variables: challenges and lessons learnt

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Operated through a consortium, led by vito
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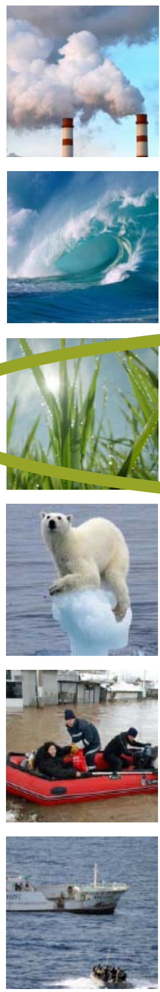

ATMOSPHERE MONITORING

MARINE ENVIRONMENT MONITORING

LAND MONITORING

CLIMATE CHANGE

EMERGENCY MANAGEMENT

SECURITY

Copernicus Services
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LAND MONITORING

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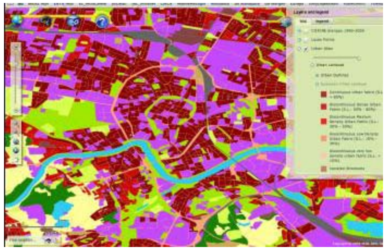
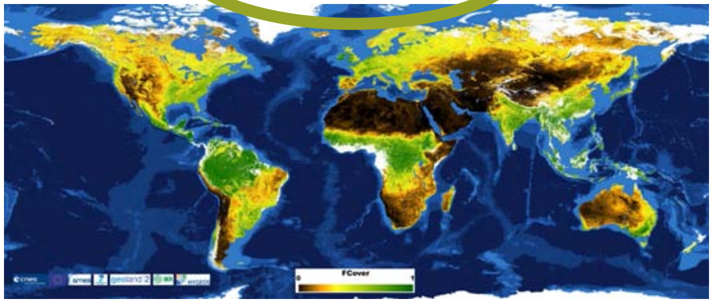
IN-SITU

LOCAL



PAN-EUROPEAN

GLOBAL



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Copernicus Global Land Service
Objectives

Support EU Policies in the following areas:

- Agriculture & food security
- Land degradation & desertification
- Forest & water resources management
- Biodiversity
- Rural development
- Climate change







Copernicus Global Land Service

Portfolio - http://land.copernicus.eu/global

VEGETATION

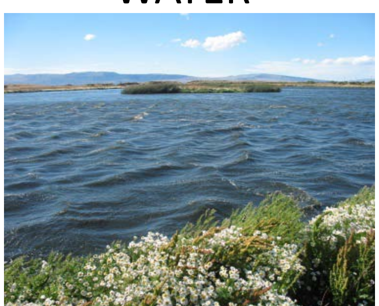
- Leaf Area Index (LAI)
- Fraction of Absorbed PAR
- Fraction of vegetation cover (FCOVER)
- Normalized Difference Vegetation Index (NDVI)
- Vegetation Condition Index
- Vegetation Productivity Index
- Dry Matter Productivity
- Burnt Area
- Dynamic Land Cover (100m)

ENERGY

- Top-of-Canopy reflectance
- Surface Albedo
- Land Surface Temperature
- Soil Water Index
- Surface soil moisture
- Radiation Fluxes

IN OPERATION
IN DEVELOPMENT

WATER



- Water Bodies
- Lake surface water temperature
- Lake and river water level
- Lake surface reflectance
- Lake turbidity
- Lake trophic state

CRYOSPHERE

- Snow water extent
- Snow water equivalent

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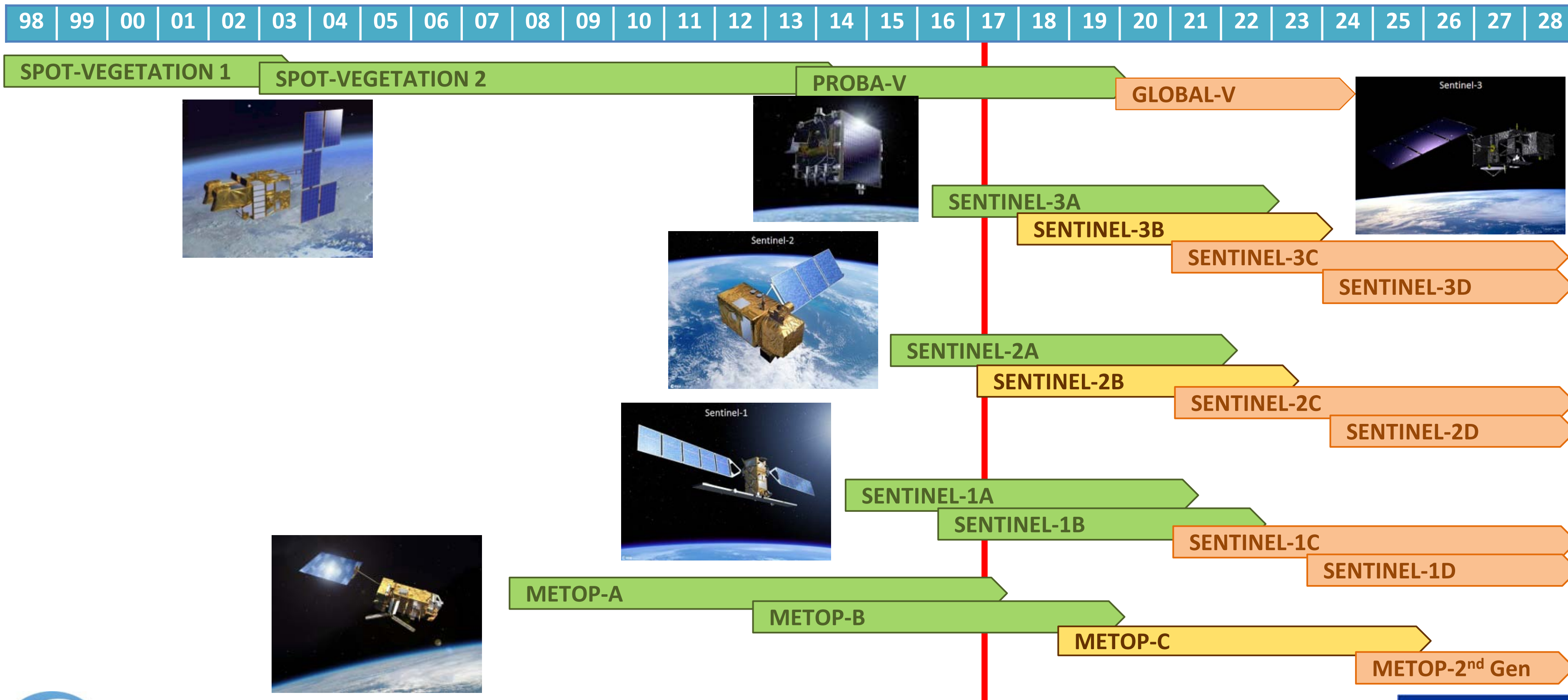
Continuity and Sustainability

Sensors for global ecosystems monitoring



Instruments characteristics

	VGT2 on SPOT5	VGT on PROBA	OLCI on Sentinel-3	MSI on Sentinel-2
Swath	2250 km	2295 km	1270 km	290 km
Instrument concept	Linear array of CCD detectors	3 cameras with 2 focal planes (VNIR and SWIR)	5 tilted cameras	Push broom imager
Local overpass time	10:30	10:45 (drift from launch)	10:00	10:30
Revisit time (at the equator)	2 days	2 days	<2.2 days (S3A) <1.1 day (S3A + S3B)	10 days (S2A) 5 days (S2A+S2B)
Spectral bands (nm)	Blue [0.43-0.47] Red [0.61 – 0.68] NIR [0.78-0.89] SWIR [1.58-1.75]	Blue [0.447-0.493] Red [0.61-0.69] NIR [0.77-0.893] SWIR [1.57-1.65]	21 bands in the range [0.4 – 1.02]	13 bands in the range [0.43 – 2.28]
Spatial Resolution	1.15km	VNIR: 100m nadir; 333m edge SWIR: 200m nadir; 666m edge	300m	10m, 20m, 60m depending on bands

Different concepts and designs

PROBA-V vs SPOT / VGT: similar but not identical

Missions products

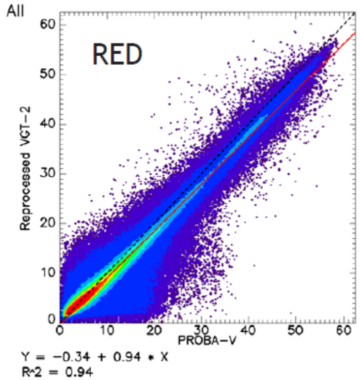
	SPOT/VGT	PROBA-V	Sentinel-3	Sentinel-2
TOA radiances			OLCI & SLSTR	Granules
TOA reflectances	VGT-P (segments)	Segments; S1 and S10 synthesis	VGT-P like (1km)	Tiles
TOC reflectances	daily (S1) and 10-days (S10) synthesis	S1 and S10 synthesis	SYN=OLCI+SLSTR (300m) VGT-S1 & VGT-S10 like (1km)	(using Sentinel-2 Toolbox)

Similar product levels but different processing, e.g. for atmospheric correction, time compositing, … and different formats

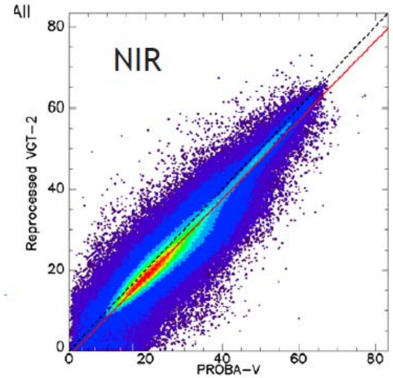
Statement

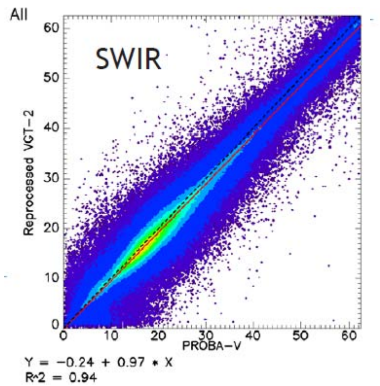
- **Given**
  - the different concepts and designs of EO sensors
  - the different processing in ground segments
  - the lack of harmonized products across-missions (e.g. inter-calibrated reflectances)
  - the different grids, projections and formats

- **It is very challenging to retrieve consistent long time series of land surface biophysical variables**



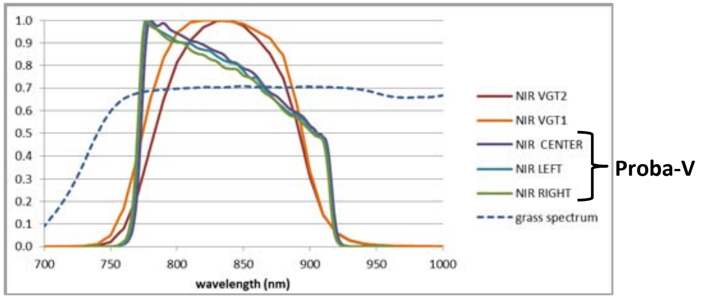
Similarity between PROBA-V and VGT:
- **view zenith angle <30°**
- **same view azimuth angle**





How to deal with these differences?

- **Define and apply spectral corrections**
  - On TOA and TOC reflectances
  - On NDVI

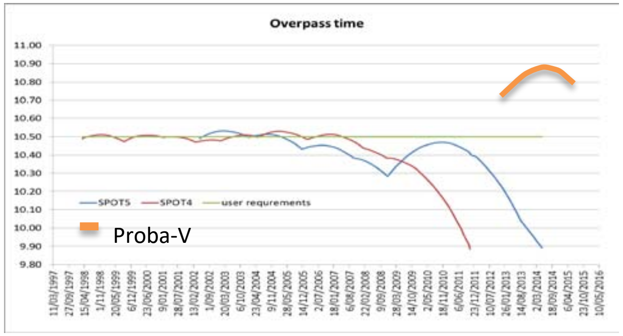


- **Adapt the thresholds for detection of contaminated pixels (snow, clouds, shadows)**

Detection of thin clouds (in black)

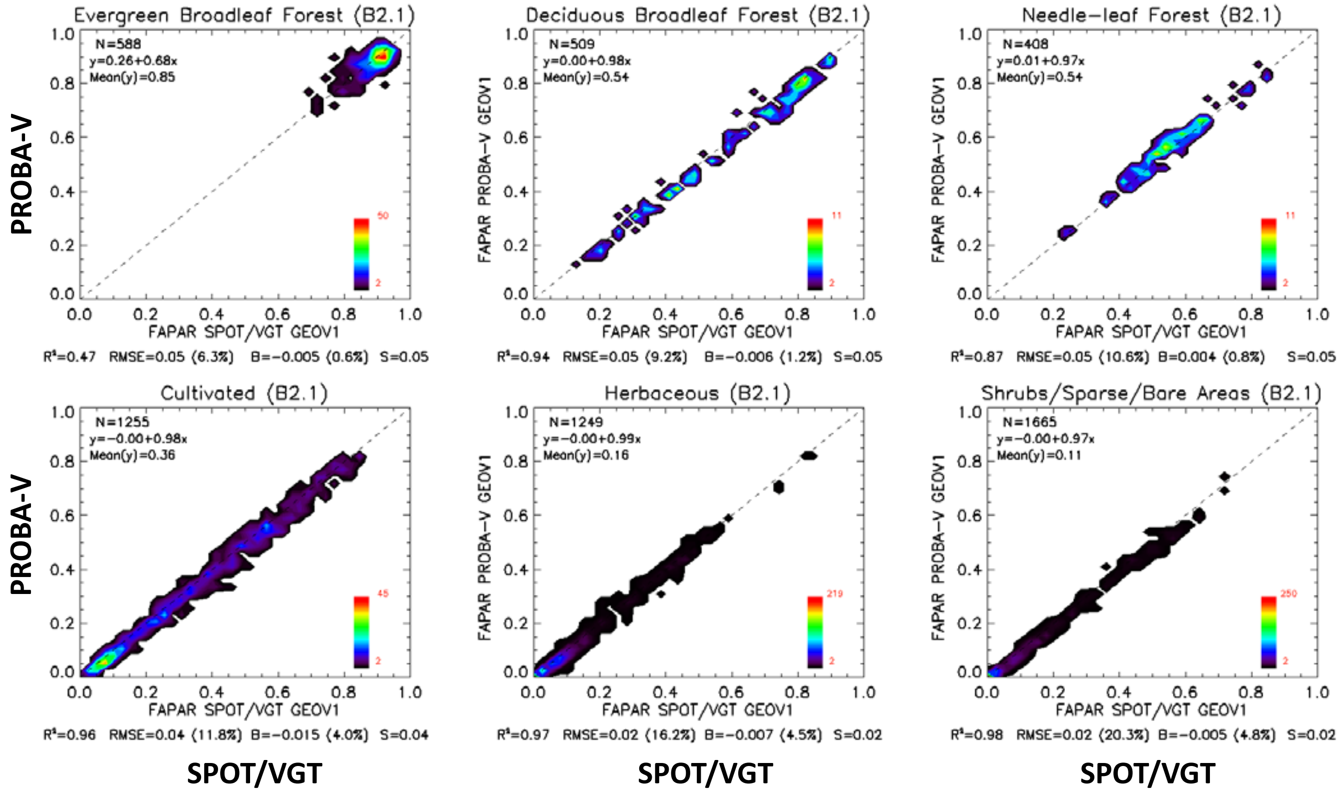
- **Use BRDF correction to remove the differences in overpass time**

- **Rescale the estimates of biophysical variables**



Impact on FAPAR

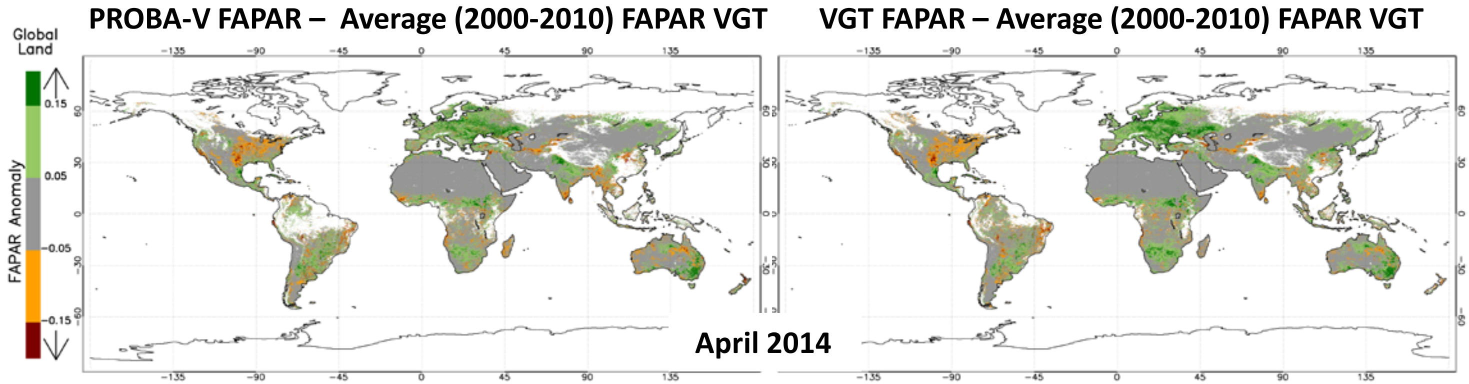
FAPAR is the fraction of sun radiation used by vegetation for the photosynthesis



From GIOGL1_QAR_FAPAR1km-V1_I1.30.pdf available on http://land.copernicus.eu/global/

- **Global & overlap period (Nov'2013 – May 2014)**
- **Good agreement, within GCOS requirements (RMSE < 0.05)**

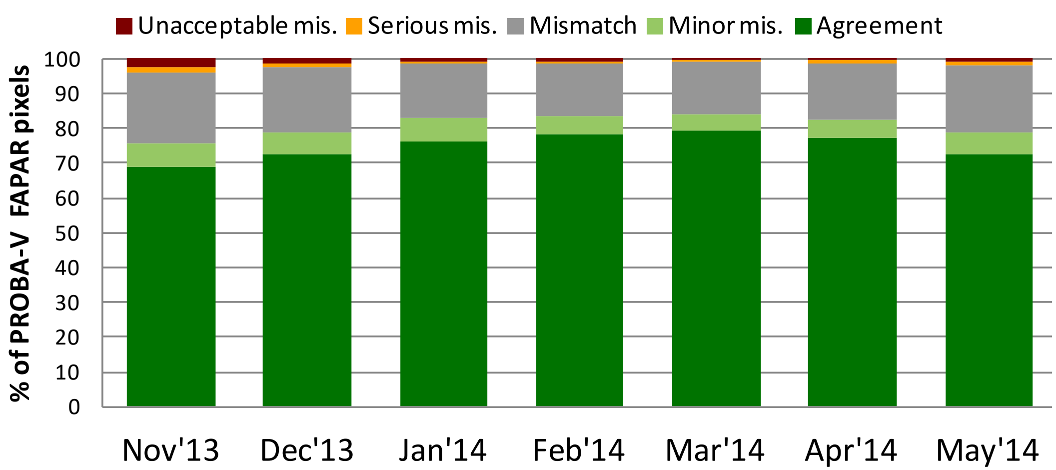
Impact on FAPAR anomalies



From GIOGL1_QAR_FAPAR1km-V1_I1.30.pdf available on http://land.copernicus.eu/global/

Anomaly Classes	FAPAR diff. with VGT Climato
Large increase	>0.15
Small increase	[0.05, 0.15]
No change	[-0.05, 0.05]
Small decrease	[-0.15, -0.05]
Large decrease	<-0.15

FAPAR anomaly compares the current health condition of vegetation with an average



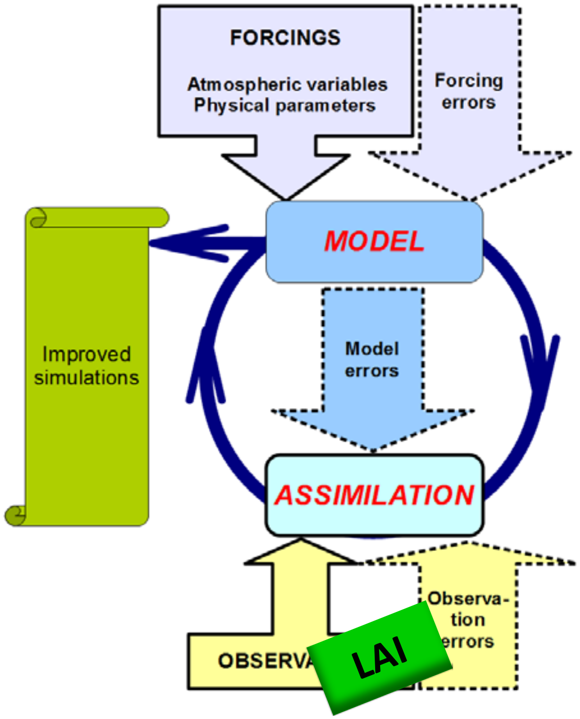
Agreement for Classes	Condition
Agreement	Same class of anomaly
Minor mismatch	Same sign of anomaly, but different magnitude ("small" vs "large")
Mismatch	One is "no change" and the other is " small " change (either increase or decrease)
Serious mismatch	One is "no change" and the other is " large " change (either increase or decrease)
Unacceptable mismatch	Anomalies with opposite sign (any magnitude)

From Meroni et al., IEEE TGRS, 2016

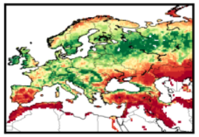
Sensor transition may cause artificial anomalies

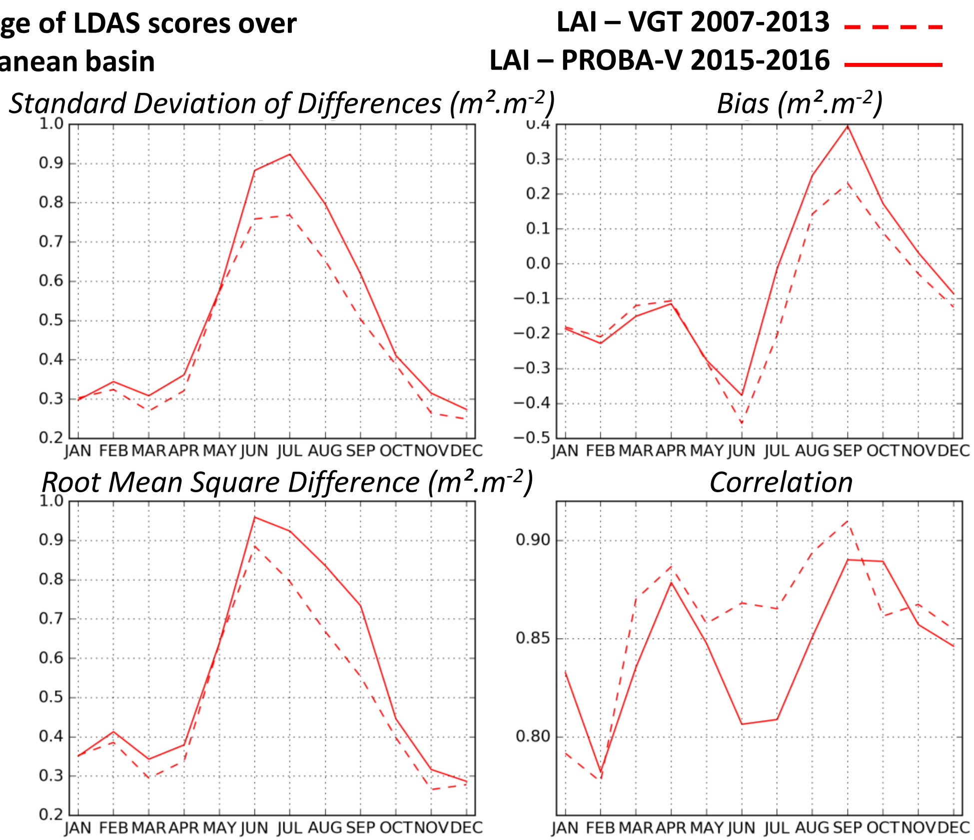
Impact on assimilation

Land Data Assimilation System



Monthly average of LDAS scores over Euro-Mediterranean basin





From CGLOPS1_SQE2016-CCR_I1.00.pdf available soon on http://land.copernicus.eu/global/

Small impact of sensor transition on assimilation performance must be confirmed with PROBA-V longer time period

Lessons learnt

- **Too many differences in sensor designs and data processing make full agreement across missions difficult**

- **The assumptions "*PROBA-V is VGT-like*" and "*S3 SYN is VGT-like*" are not true**

- **It takes time to adapt methodologies to new sensors data to ensure the time series consistency as well as possible**

- **Users must be aware of these limitations, especially of the impact on anomalies**

Conclusions & Recommendations

- **Not all input data differences can be corrected with biophysical retrieval algorithms**
  ⇒ Unavoidable discrepancies in time series

- **Users must accept these discrepancies**

- **Assimilation system can manage quality information from biophysical time series (when available)**

- **Harmonization across missions (SPOT/VGT, PROBA-V, S3, S2) and resolutions (1km, 300m, 100m) is required:**
  - Mission-specific data is not sufficient
  - Inter-calibration of reflectances, similar pre-processing (e.g atmospheric corrections), equivalent grid, projections, format
  - Inter-calibration requires enough overlap across missions
  - Close cooperation between missions/ground segments is mandatory
  - Reprocessing of historic archives should be planned regularly

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JRC
EUROPEAN COMMISSION

- **Global Land Operations**
  - **Consortium "Production of vegetation & energy products" led by VITO**

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  - **Consortium: "Production of Cryosphere & water products" led by CLS**
  - **Consortium: "Distribution" led by VITO**
  - **Consortium: "Evaluation & User group" led by Spacebel**

- **Hot Spot Monitoring**
  - **Consortium «Mapping» led by eGEOS**
  - **Consortium «Validation» led by IGT**

- **Ground-based Observations Collection**
  - **Consortium led by ACRI-ST**

- **Sentinel-2 Global Mosaic *(call open)***

European Commission DG GROW