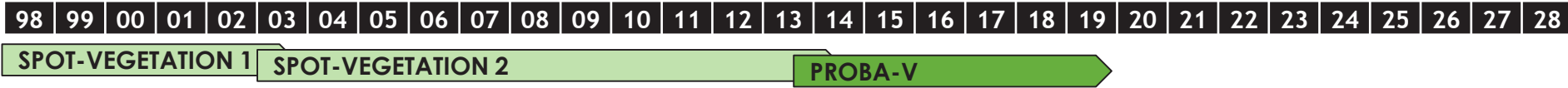




Copernicus Global Land Service NDVI V3 – BRDF correction for improved temporal consistency

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Context



Copernicus Global Land Service
Providing bio-geophysical products of global land surface

Copernicus
 Europe's eyes on Earth

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 Water
 Cryosphere
 Hot Spots

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The Copernicus Global Land Service (CGLS) is a component of the Land Monitoring Core Service (LMCS) of Copernicus, the European flagship programme on Earth Observation. The Global Land Service systematically produces a series of qualified bio-geophysical products on the status and evolution of the land surface, at global scale and at mid to low spatial resolution, complemented by the constitution of long term time series. The products are used to monitor the vegetation, the water cycle, the energy budget and the cryosphere.

Latest news

TOC-r 1km time series completely reprocessed
 Mon, 12 Feb 2018

Sentinel 3A adds more Water Level observations
 Mon, 12 Feb 2018

Full time series of DMP and GDMP 1km available

land.copernicus.eu/global

Overview of the product portfolio

The Copernicus Global Land Service reliably provides a set of biophysical variables which describe the state and the evolution of the vegetation, the energy budget, the water cycle and the cryosphere over the land surface at global scale. The below tables show the availability of the latest major versions in recurrent time. For more details on the definition, quality, development or version history of the products, as well as the available archive (time series), please visit the individual product page.

From medium to high resolution		
Theme	Variable	Spatial Resolution
Vegetation	Land Cover	Moderate 100m
From coarse to medium resolution		
Theme	Variable	Spatial Resolution
		Coarse >=1km
		Medium 300m
Vegetation	Fraction of photosynthetically active radiation absorbed by the vegetation	In production
	Fraction of green vegetation cover	In production
	Leaf Area Index	In production
	Normalized Difference Vegetation Index	In production
	Vegetation Condition Index	In production
	Vegetation Productivity Index	In production
	Dry Matter Productivity	In production
	Burnt Area	In production
	Soil Water Index	In production
Energy	Surface Soil Moisture	In development
	Land Surface Temperature	In production
	Top Of Canopy Reflectance	In production
	Surface Albedo	In production
	Downward Short- and Longwave Fluxes at the surface	In development
Water	Water Status	In development
	Lake Surface Water Temperature	In development
	Lake Water Quality (reflectance, turbidity, trophic state)	In development
Cryosphere	Lake Ice Extent	In development
	Snow Cover Extent	In development
	Snow Water Equivalent	In development
Non-gridded products		
Theme	Variable	Rivers and Lakes
Water	Water Level	In production

Consistent archive & NRT
 Long Term & Reliable Provision
 Validated & Continuous
 monitoring

Table 1: Algorithm differences between successive versions of NDVI product

NDVI versions	Algorithm differences
Version 0	Standard SPOT/VGT C2 NDVI products, derived from S10 products
Version1	Derived from SPOT/VGT P C2 products, normalized surface reflectance, 30-days composite, updated every 10 days using a sliding window
Version 2.0	Derived from SPOT/VGT C2 and PROBA-V C0 S10 products, with incorporation of the Status Map and land mask.
Version 2.1	A spectral harmonization and a bias correction between VGT2 and PROBA-V is performed. Bug fix for NDVI V2.0
Version 2.2	Derived from SPOT/VGT C3 and PROBA-V C1 S10 products, with incorporation of the Status Map and land mask. A spectral harmonization between VGT1 and VGT2 is performed.
Version 3	Angular corrected composite, derived from SPOT/VGT C3 P segments and PROBA-V C1 Level2A products; normalized surface reflectance, 10-days composite window (extendable to 16 days), updated every 10 days using a sliding window. A spectral harmonization between VGT1 and VGT2 is performed.



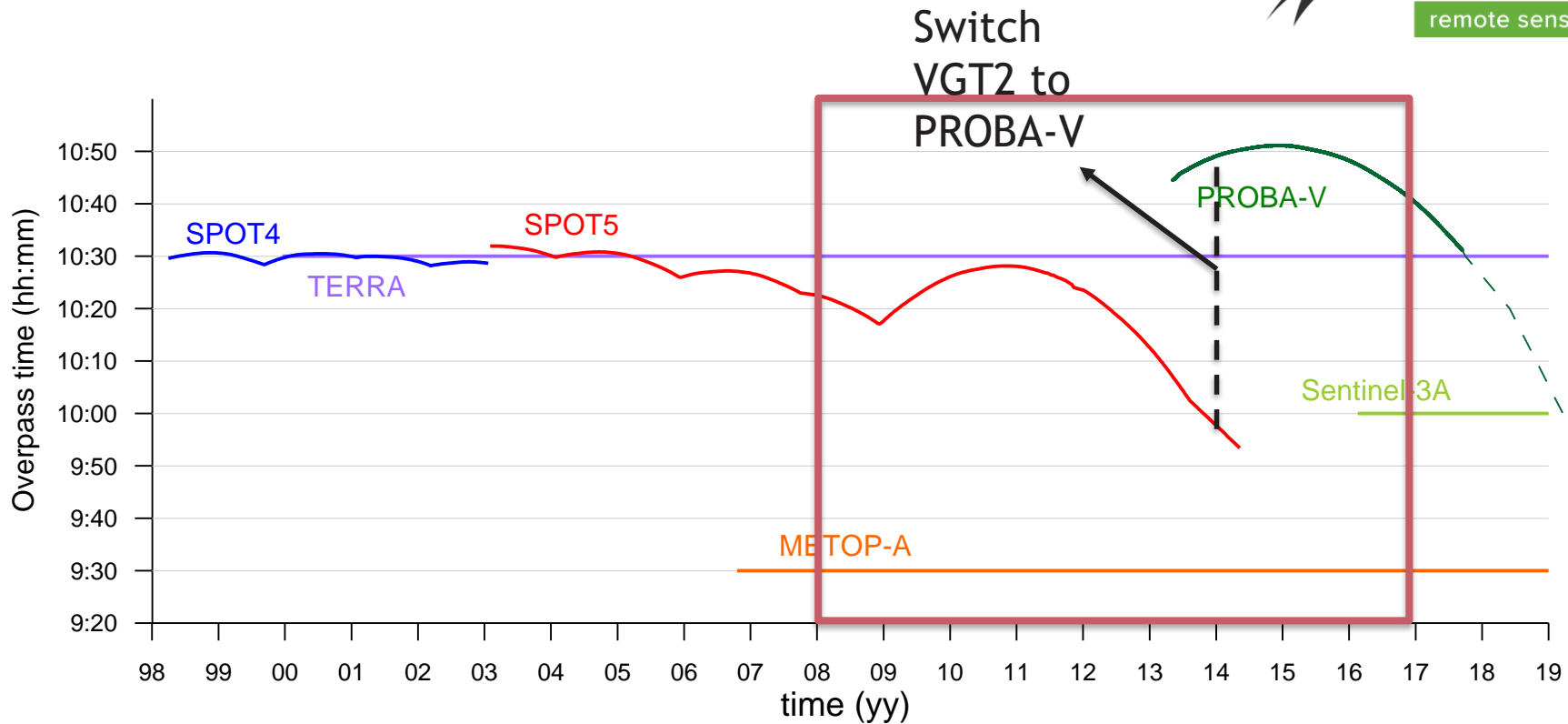
Standard CVB S10 NDVI

Current product
In operations

Beta version
Release candidate

[CGLOPS ATBD NDVI V3]

Differences in overpass times

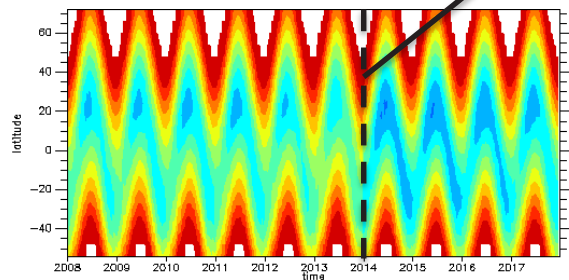


Effect on illumination angles

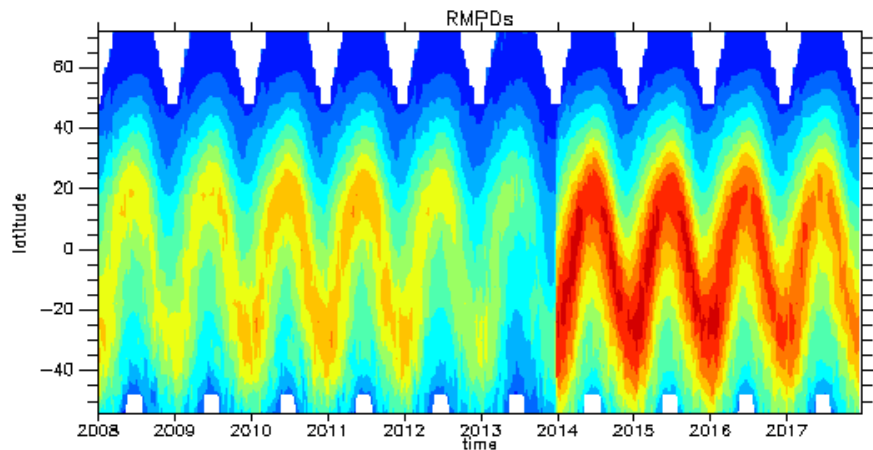
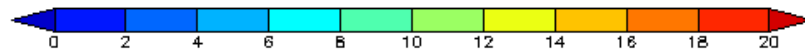
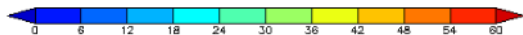
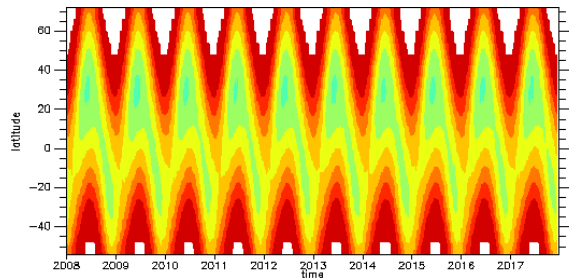
Mean SZA

Switch
VGT2 to PROBA-V

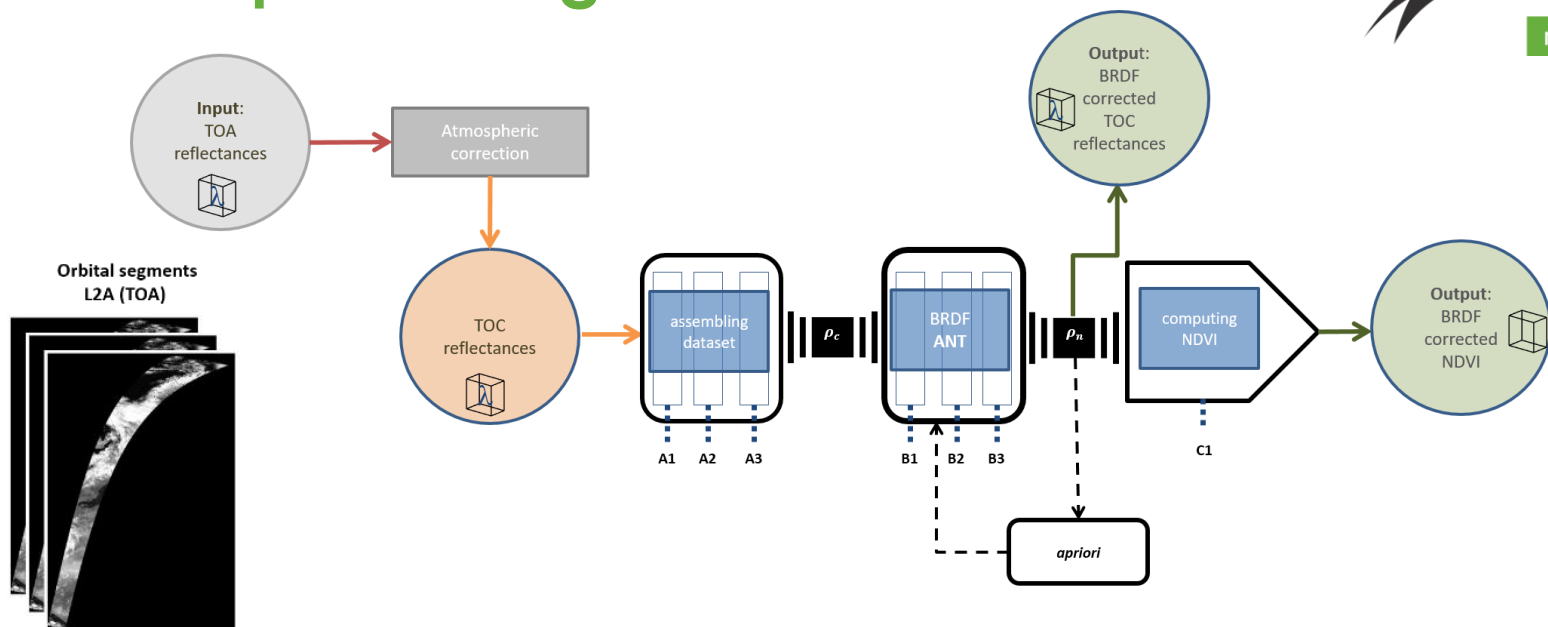
VGT2 - PROBA-V



METOP-A



NDVI V3 processing



- **A1 – Accumulation** : Selecting clear observations acquired over the last 16 days.
- **A2 – Compositing** : Using an adaptive window to select when possible only *fresh* (acquired in the previous 10 days) observations.
- **A3 – Observations weighting**: temporal and angular.
- **B1 – BRDF model**: Semi-empirical BRDF model from Roujean et al. (1992).
- **B2 – Inversion**: Weighted least-square inversion with apriori constraints.
- **B3 – Normalization**: Set reflectance to a common Sun-sensor geometry (*Nadir viewing and SZA at local 10:30AM*).
- **C1 – NDVI** : Computing NDVI using RED and NIR normalised reflectances

Quality Assessment

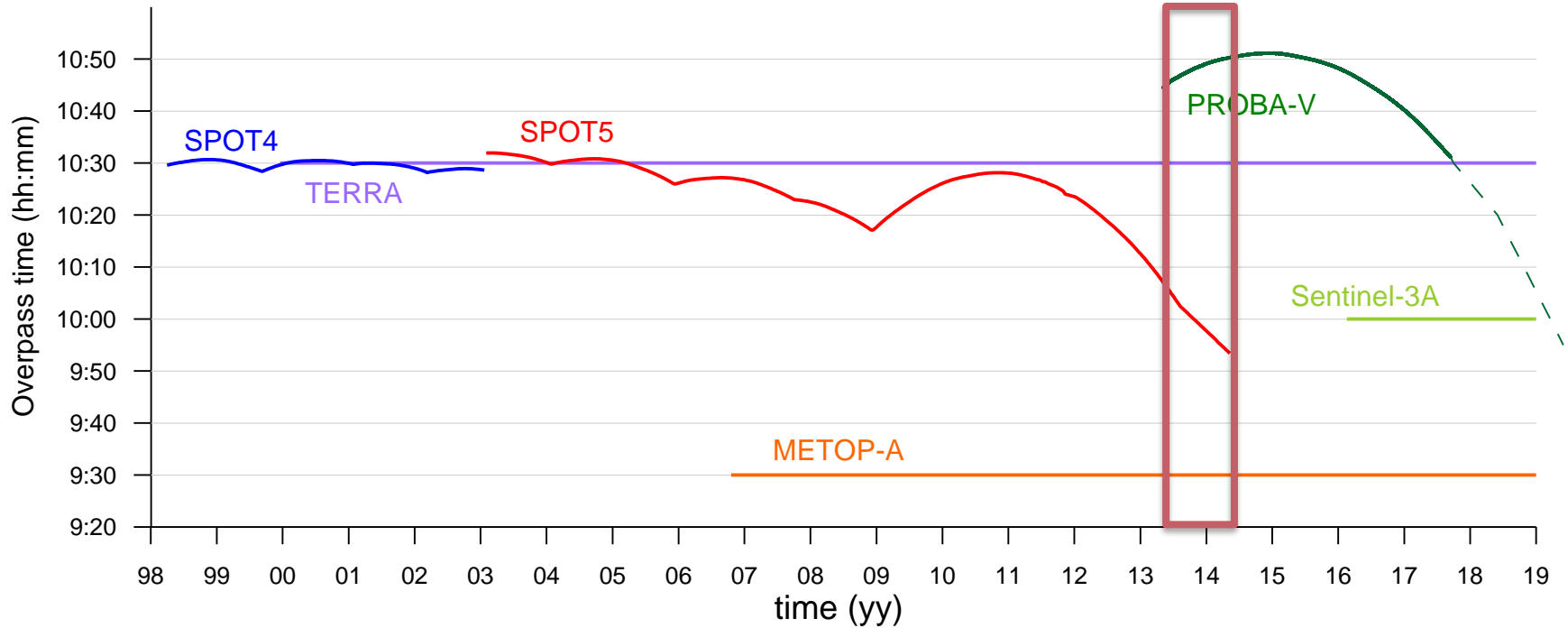
Research questions – NDVI



1. What is the **difference between NDVI V3 and NDVI V2.2** in terms of statistical, spatial and temporal consistency?
2. What is the **statistical consistency between SPOT/VGT and PROBA-V** for their overlapping period? How do the results based on NDVI V3 compare to those of NDVI V2.2?
3. What is the **temporal consistency of NDVI V3** (combined series of SPOT/VGT and PROBA-V) in comparison to AVHRR and MODIS? How do the results based on NDVI V3 compare to those of NDVI V2.2?
4. What is the **spatial and statistical consistency of NDVI V3** in comparison to AVHRR and MODIS? How do the results based on NDVI V3 compare to those of NDVI V2.2?
5. What is the temporal variation and spatial distribution of the **product completeness** of NDVI V3 in comparison to AVHRR and MODIS? How do the results based on NDVI V3 compare to those of NDVI V2.2?

[CGLOPS QAR NDVI V3]

Statistical consistency between SPOT/VGT and PROBA-V?



Statistical consistency between SPOT/VGT and PROBA-V?

Frequency distribution per biome

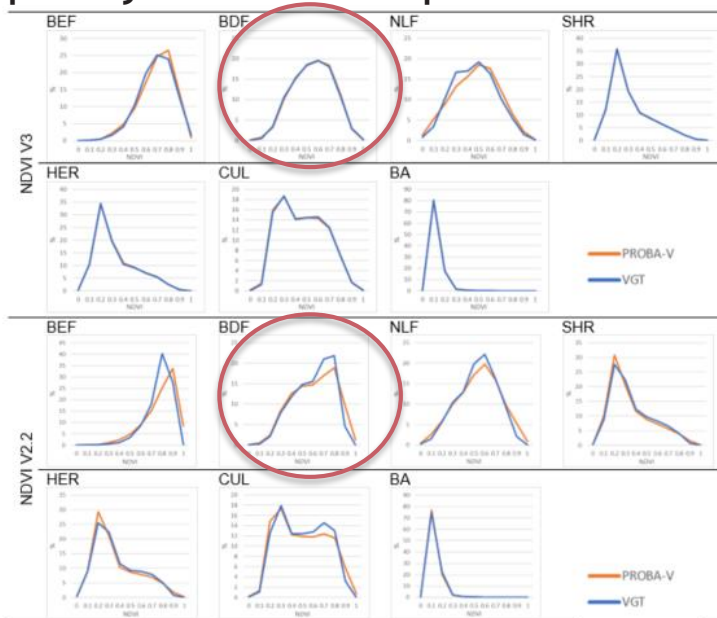
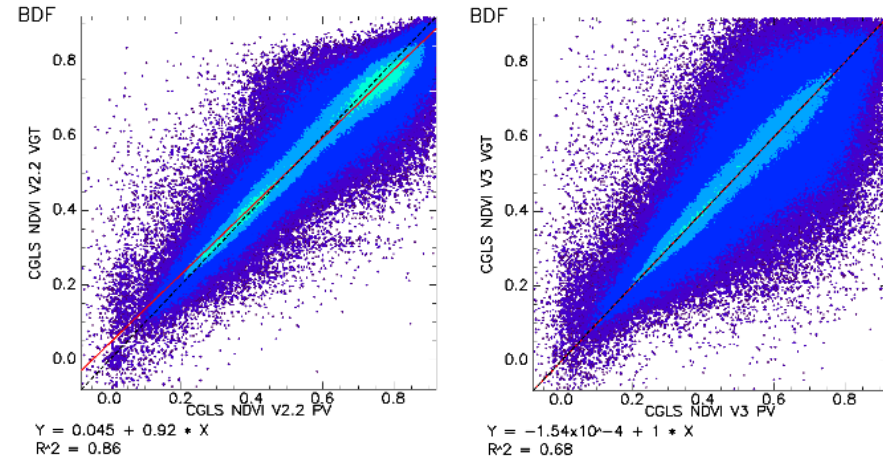


Figure 13: Frequency distributions over 7 different biomes using the 'noMask' sampling. Pairwise comparison of physical NDVI values over the overlapping period of SPOT/VGT (blue) and PROBA-V (orange) using the NDVI V3 algorithm (top) and the NDVI V2.2 algorithm (bottom). X-axis: NDVI values in steps of 0.1, Y-axis: percentage of occurrence.

GMR analysis



[CGLOPS QAR NDVI V3]

Statistical consistency between SPOT/VGT and PROBA-V?

Analysis of bias per biome

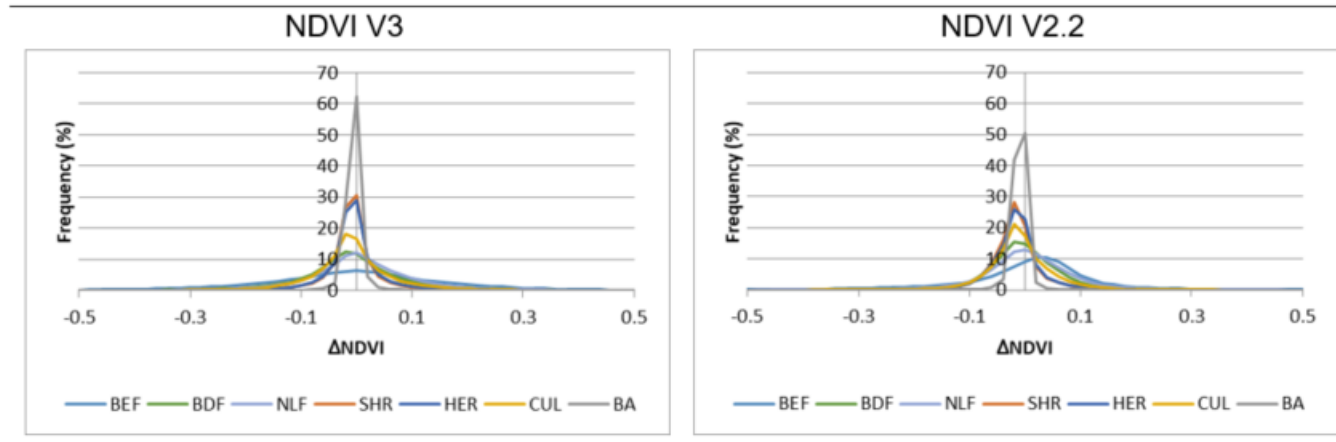
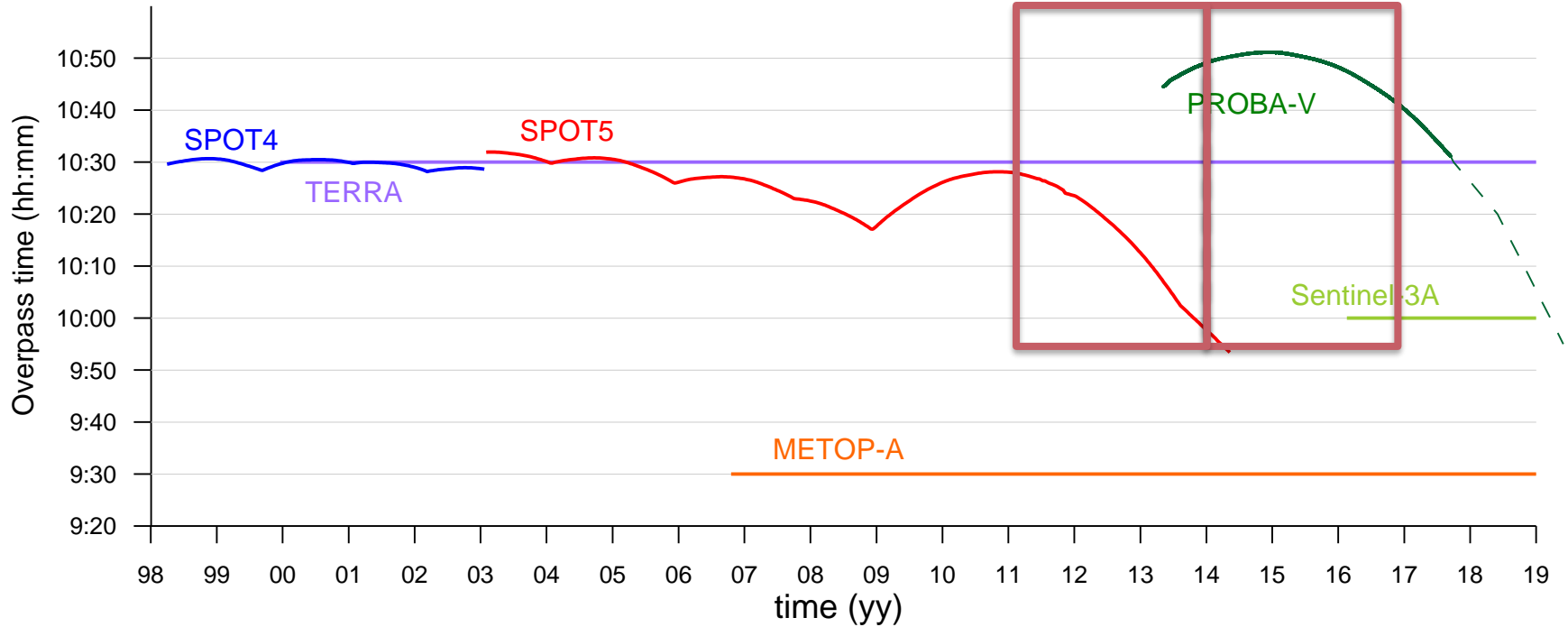


Figure 15: Frequency histogram of the bias between NDVI values (PROBA-V minus SPOT/VGT) per biome over the overlapping period using the NDVI V3 algorithm (left) and the NDVI V2.2 algorithm (right)

Temporal consistency?



Temporal consistency?

Analysis of bias for 2011-2013 (VGT2) vs. 2014-2016 (PROBA-V)

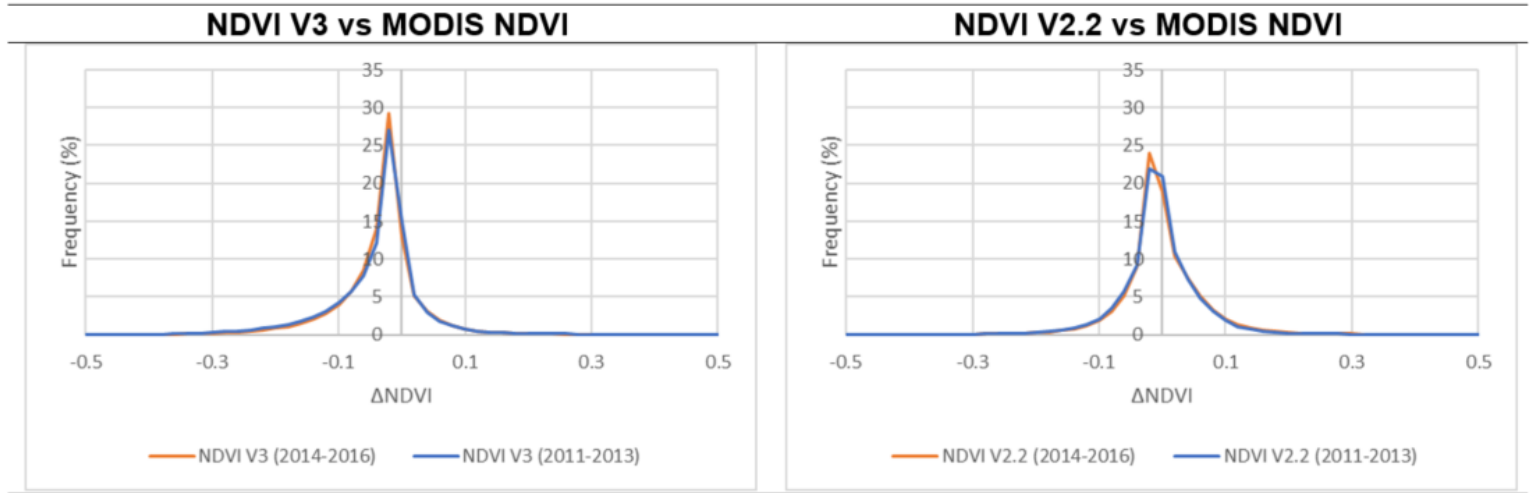
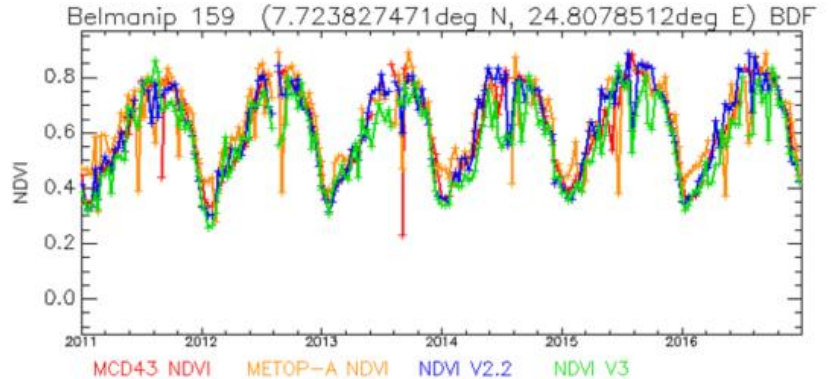
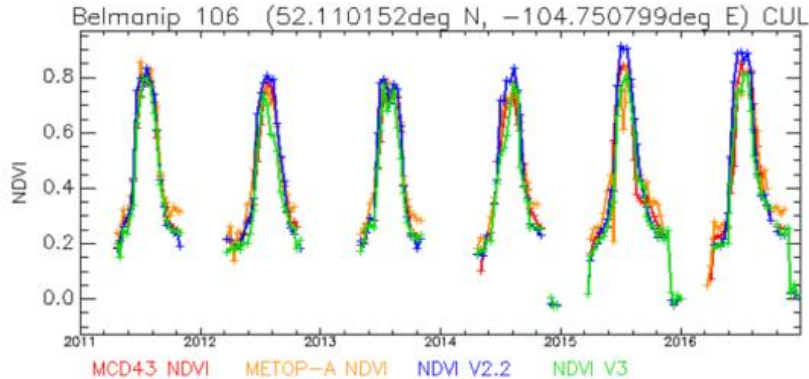
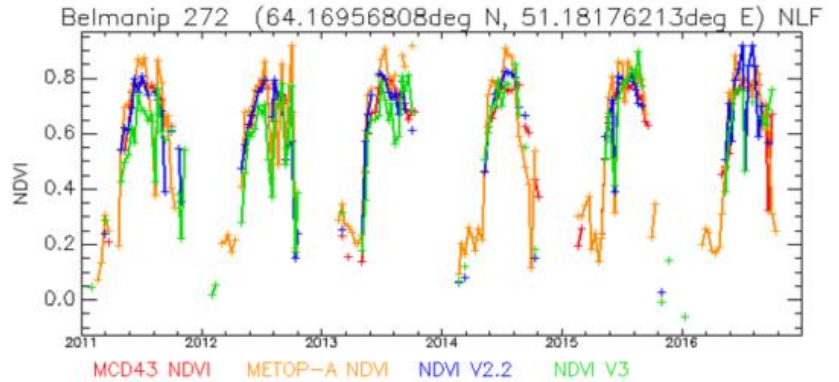
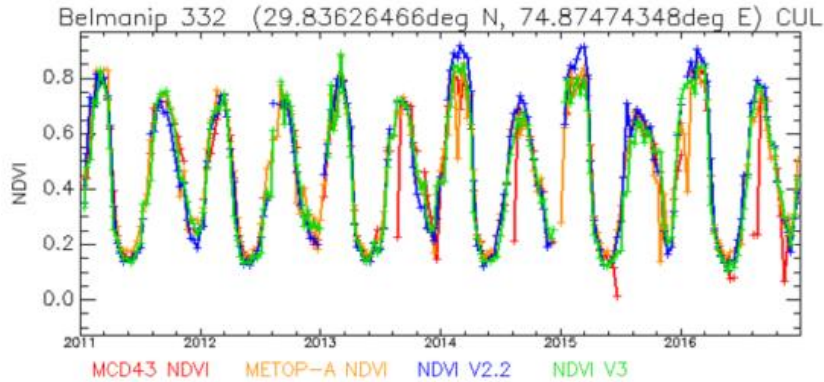


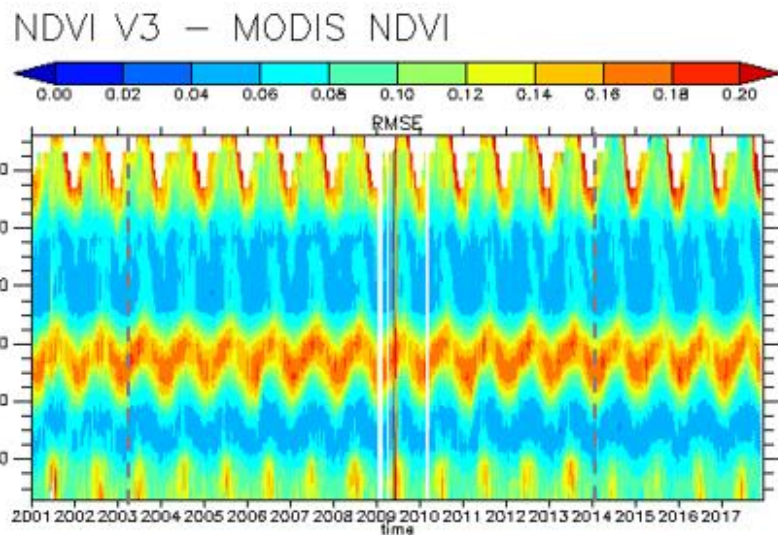
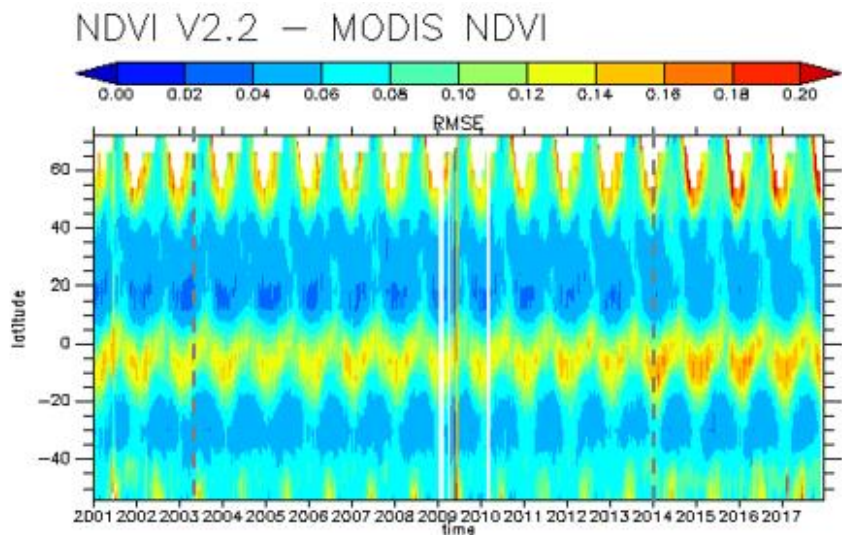
Figure 32: Bias histogram of NDVI V3 (left) resp. NDVI V2.2 (right) vs. MODIS NDVI for 2011-2013 (blue) and 2014-2016 (orange)

Temporal consistency?



[CGLOPS QAR NDVI V3]

Temporal consistency?



[CGLOPS QAR NDVI V3]

Quality Assessment

Research questions – NDVI anomalies



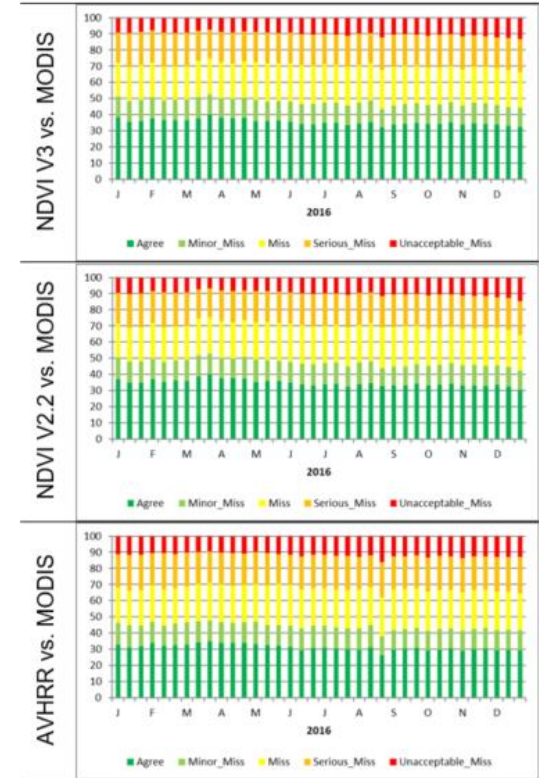
1. What is the **spatial consistency** of VCI, VPI and SDVI derived from NDVI V3 in comparison to VCI and VPI from AVHRR and MODIS? How do the results based on NDVI V3 compare to those of NDVI V2.2?
2. What is the **temporal consistency** of VCI, VPI and SDVI derived from NDVI V3 (combined series of SPOT/VGT and PROBA-V) in comparison to AVHRR and MODIS? How do the results based on NDVI V3 compare to those of NDVI V2.2?
3. What is the **temporal realism**, i.e. verification of VCI, VPI and SDVI spatial and temporal patterns with field data or other reference products (e.g. crop bulletins)? How do the results based on NDVI V3 compare to those of NDVI V2.2?

Temporal consistency of NDVI anomalies

Anomaly class agreement (cfr. Meroni et al., 2016)

VCI	VPI	SDVI	Anomaly class
< 0.1	< 10%	< -1.5	very negative
0.1 – 0.3	10 – 30%	-1.5 – -0.5	negative
0.3 – 0.7	30 – 70%	-0.5 – 0.5	normal
0.7 – 0.9	70 – 90%	0.5 – 1.5	positive
> 0.9	> 90%	> 1.5	very positive

Label	Condition	Colour
Unacceptable mismatch	Datasets indicate anomaly with opposite sign ('positive' vs. 'negative', no matter the magnitude)	Red
Serious mismatch	One dataset indicates 'normal' and the other 'very positive' or 'very negative'	Orange
Mismatch	One dataset indicates 'normal' and the other 'positive' or 'negative'	Yellow
Minor mismatch	Both datasets have the same sign of anomaly but different magnitude	Light Green
Agreement	Both datasets indicate the same anomaly class	Dark Green



[CGLOPS QAR NDVI V3]

Conclusions



- Release candidate NDVI V3
- Discrepancies due to difference in overpass time VGT2 and PROBA-V are reduced
- Effects are larger for more densely vegetated areas (more subject to anisotropy effects)
- Increased temporal consistency
- Evaluation over NDVI anomalies is not conclusive



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