Comparison between SPOT-VGT and PROBA-V

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1 Introduction

This short note describes the comparison between SPOT-VGT and PROBA-V, before and after their re-processing.

The SPOT-VGT archive was re-processing in 2015-2016 and resulted in the Collection 3 archive (VGT-C3). Likewise, the 'old' archive is referred to as VGT-C2.

The PROBA-V archive (Collection 0 or PV-C0) was re-processed in 2016-2017 and resulted in the Collection 1 archive (PV-C1).

More information on the re-processing and its evaluation for both missions can be found in:

- Toté, C., E. Swinnen, and S. Sterckx, Evaluation of the re-processed VGT1 and VGT2 archive, Final report, April 2016, 70 p.
    - Online: Link

- Toté, C., E. Swinnen, W. Dierckx, S. Sterckx, and D. Clarijs, Evaluation of the re-processed PROBA-V archive (Phase 2), Interim report, October 2016, 74 p.
    - Online: Link

Here, we briefly describe the inter-comparison of the data sets over their overlapping period before and after re-processing and the impact of the re-processing on the consistency of the data sets. The analysis was applied on 10-daily composites from November 2013 – May 2014.

2 Method

2.1 Overall approach

The global images were systematically spatially subsampled over the whole globe, taking the central pixel in a window of 21 by 21 pixels. This subsample is representative for the global vegetation patterns and considerably reduces processing time. The relation between the observation and its viewing and illumination geometry is retained.

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For the pairwise comparison between SPOT-VGT and PROBA-V Top-of-Canopy (TOC) reflectances and NDVI, pixels are further sampled using the following conditions:

- Clear observations: use only observations that are not identified as bad observation (cloud/shadow/snow/unreliable) in the status map that is delivered with the product
- Viewing zenith angle (VZA) less than 30°: use only observations with off-nadir viewing angles smaller than 30°
- No mixed scatter observations: use only observations that are both in either the East or the West direction, i.e. either in backscatter or forward scatter direction.

2.2 Validation metrics

The geometric mean (GM) regression model is used to identify the relationship between two data sets of remote sensing measurements. Because both data sets are subject to noise, it is most appropriate to use an orthogonal (model II) regression like the GM regression. The GM regression model minimizes the sum of the products of the vertical and horizontal distances (errors on Y and X) and is of the form:

$$Y = a + b \cdot X$$

with

slope $b = sign(R)\frac{\sigma_Y}{\sigma_X}$

intercept $a = Y - b \cdot \bar{X}$

σ_X and σ_Y : the standard deviation of X and Y

R: the correlation coefficient

$sign()$: signum function that takes the sign of the variable between the brackets

$\bar{X}$: the mean value of X

X: Proba-V C0 or C1

Y: SPOT-VGT C2 or C3

The GM regression slope and intercept are added as quantitative information related to the scatterplots.

The **Root Mean Squared Error (RMSE)** measures how far the difference between the two data sets deviates from 0 and is defined as

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(X_i - Y_i)^2}$$

The RMSE is an expression of the overall difference, including random and systematic differences.

The **relative difference (RD)** is expressed as the median of the relative percentage difference between two data sets.

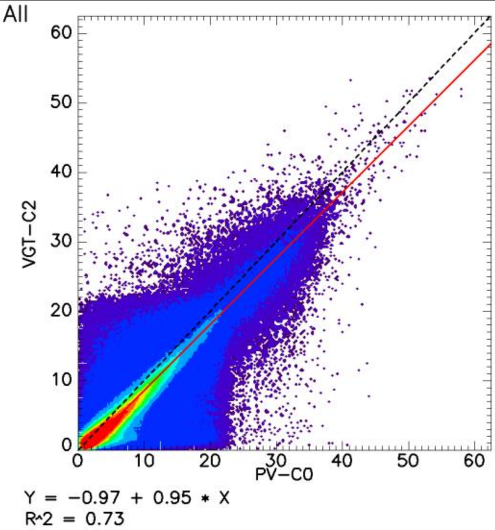
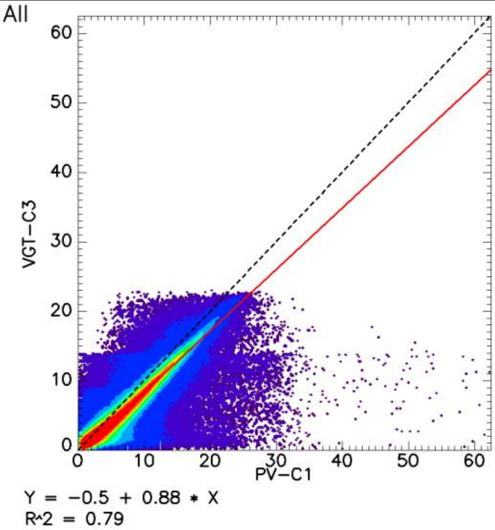
$$RD = median\left(\frac{X_i - Y_i}{Y_i}\right) \cdot 100\%$$

3 Results

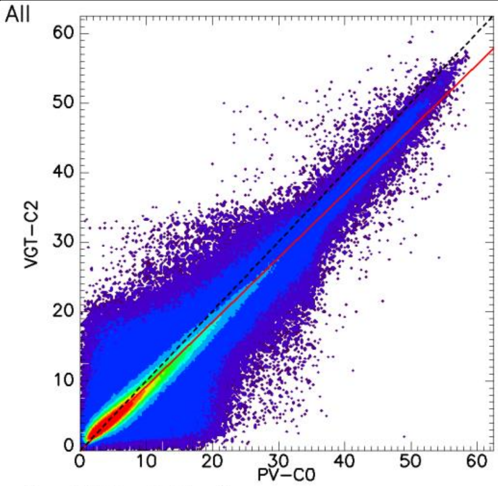
Figure 1 shows the scatterplots of all sampled pixels for the TOC reflectances and NDVI before (VGT-C2 – PV-C0) and after (VGT-C3 – PV-C1) re-processing.

In all cases, the re-processing resulted in a higher correspondence between VGT and PROBA-V (higher R^2), and in most cases also in a relationship between the two data sets with a slope of the regression line closer to 1. For the BLUE TOC reflectances, the relationship deviates more from 1 after re-processing. This is caused by the fact that the GM regression line is influenced by the larger scattering in the lower left part of the scatterplot after re-processing. Although more clouds are detected in both data sets after re-processing, there is still an amount of pixels with high BLUE TOC reflectance, which are probably undetected clouds. These impact the regression line slope, because the slope is calculated from the ratio of the standard deviation of the two data sets. If one looks at the shape of the high density cloud in the scatterplot (colours red to green), then one sees that the relationship is not deteriorated after re-processing. The horizontal lines in this scatterplot come from the cloud detection thresholds applied in the VGT re-processing (see also the evaluation report of VGT re-processing).

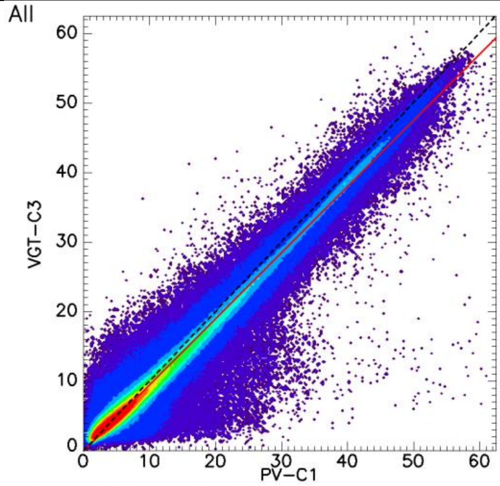
For NDVI, the agreement for low NDVI values is improved after re-processing. The non-linear shape of the point cloud is caused by the difference in overpass time, and thus different illumination conditions.

	VGT-C2 – PV-C0	VGT-C3 – PV-C1
BLUE		

RED

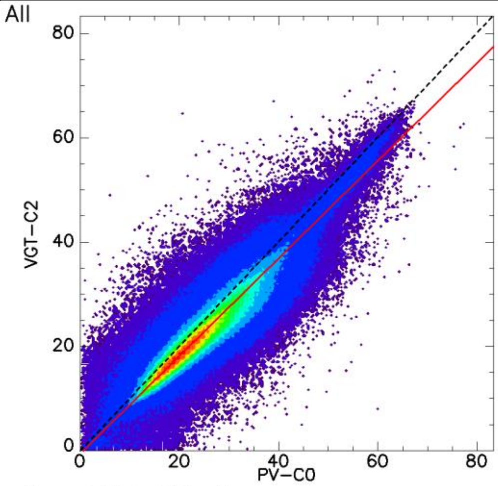


Y = 0.028 + 0.93 * X
R^2 = 0.89

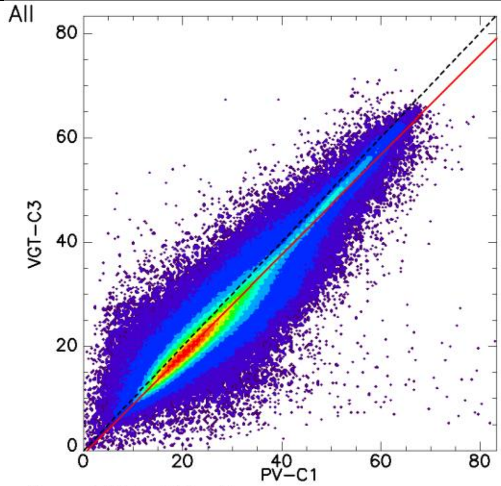


Y = −0.074 + 0.95 * X
R^2 = 0.96

NIR

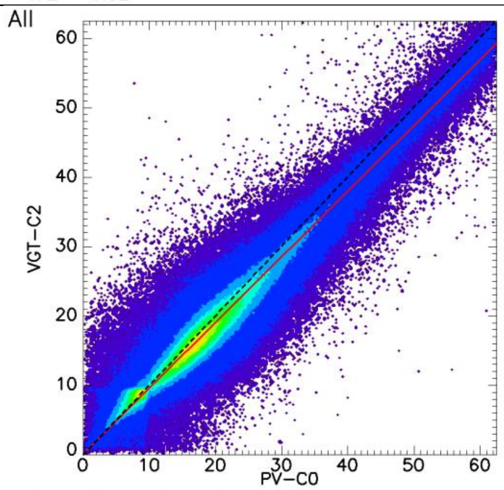


Y = −0.54 + 0.94 * X
R^2 = 0.82

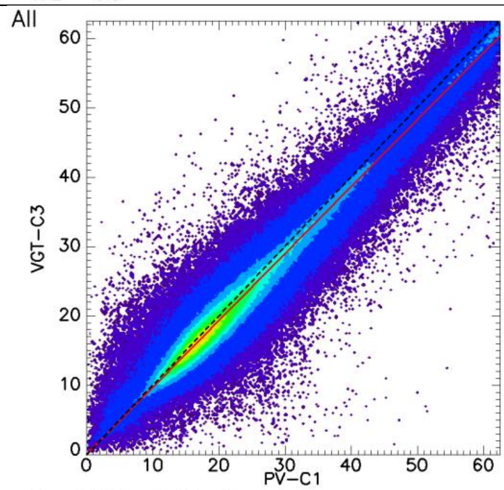


Y = −0.73 + 0.96 * X
R^2 = 0.9

SWIR



Y = 0.27 + 0.94 * X
R^2 = 0.9



Y = 0.048 + 0.97 * X
R^2 = 0.94

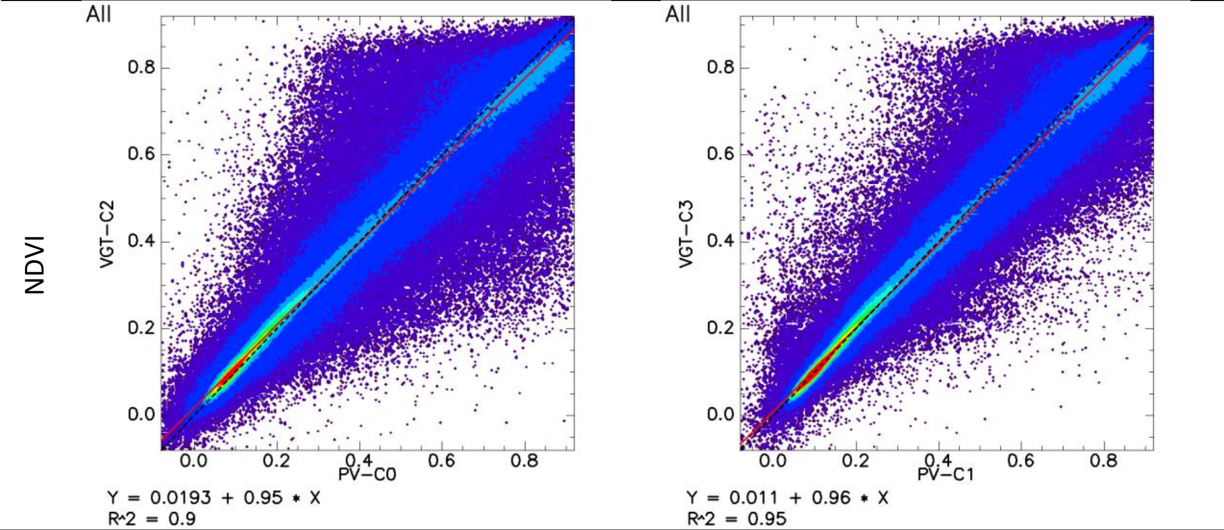


Figure 1: Scatterplots between VGT and PROBA-V before (left column) and after re-processing (right column) for BLUE, RED, NIR, and SWIR TOC reflectances and NDVI (from top to bottom row).

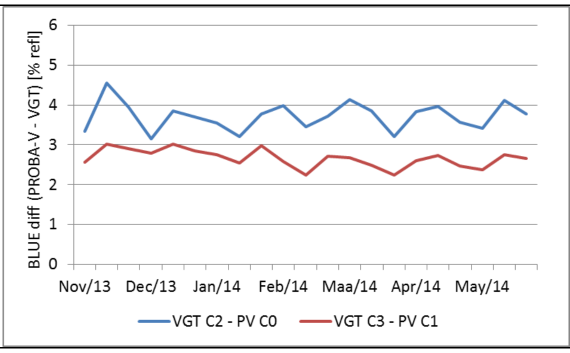
Figure 2 shows the temporal evolution of the RMSE and the relative difference (RD) between SPOT-VGT and PROBA-V before and after the re-processing for all TOC reflectance bands and NDVI.

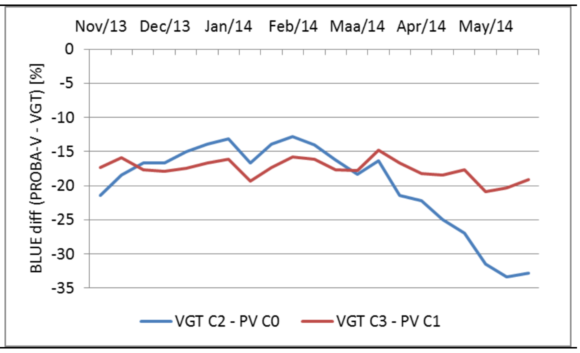
The RMSE is reduced for all bands and NDVI. The largest impact is for BLUE, RED, NIR and NDVI. The improved cloud detection and calibration changes result in this lower RMSE. For NIR and SWIR, the RMSE is more stable over time after re-processing.

The RD is almost everywhere reduced, but most importantly, is more stable over time. For all bands, the RD varied over time due to the incorrect sun-earth distance modelling in the VGT-C2 archive.

RMSE **Relative Difference**

BLUE





...

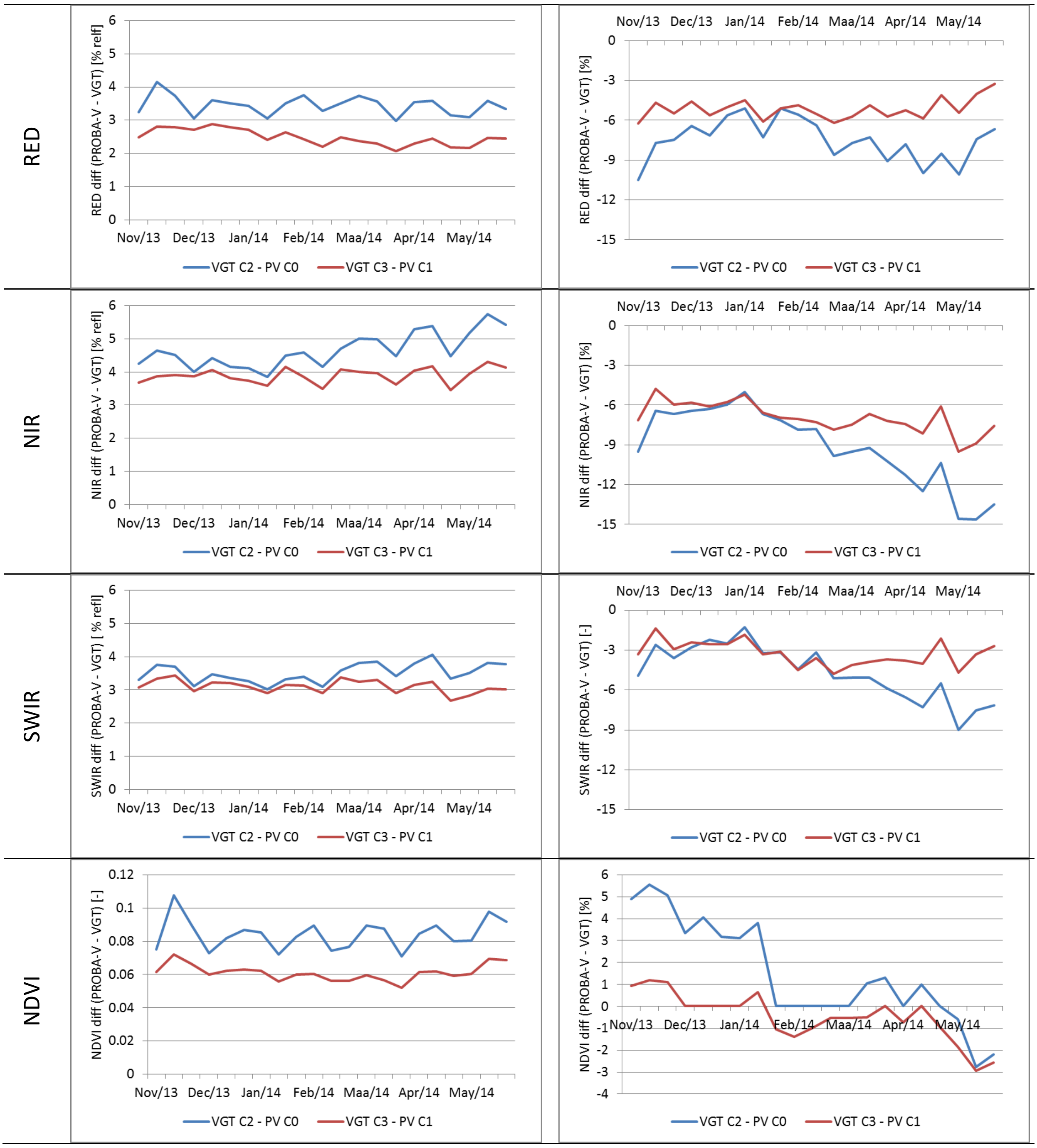


Figure 2: Temporal evolution of RMSE (left column) and relative difference (right column) between VGT and PROBA-V before re-processing and after re-processing for BLUE, RED, NIR, SWIR TOC reflectances and NDVI (from top to bottom row).

4 Conclusion

The re-processing of both archives resulted in a better agreement between the SPOT-VGT and PROBA-V data sets. The agreement is also more stable over time.

The factors that contribute to this better consistency are

- Improved cloud labelling in the status map for both sensors
- Changes in the absolute calibration of both sensors
- Improved inter-camera consistency for PROBA-V
- Correct modelling of the sun-earth distance in the VGT C3 archive

The remaining differences can be attributed to:

- Difference in absolute calibration: currently there is no inter-calibration between SPOT-VGT and PROBA-V, which means that the data sets are independently calibrated. Later this year, we will provide an estimate of the calibration bias, which users can then apply on the Top-of-Atmosphere (TOA) reflectances to obtain better consistency. The impact is of the order of a few percent and can be linearly applied on the TOA reflectances.
- Difference in overpass time between the two satellites causes differences in illumination conditions. As the TOC reflectances in the standard products are directional reflectances, the observation and illumination angles should always be taken into account when using the reflectances. Characterizing this dependency and estimating the reflectances in a standard observation and illumination geometry (BRDF correction) results in a better agreement between the SPOT-VGT and PROBA-V archives. The magnitude of the impact of this BRDF correction is depending on the underlying surface conditions, observation and illumination geometry, and the atmosphere.
- Difference in spectral characteristics, as defined by the spectral response function (SRFs) of the bands. Analysis has shown that this has a very small impact on the consistency between the VGT and PROBA-V archives. A report on this is in preparation.