proba-v

# QUARTERLY IMAGE QUALITY REPORT

## IQR#020

## Reporting period from 16/09/2018 to 15/12/2018

**Reference:** ***PROBA-V_D9_QIR-020_2018-Q4_v1.0***
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# DOCUMENT CONTROL

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# 1. Radiometric Image Quality

## 1.1. Summary

Since October 2018 a degradation model is no longer applied to the SWIR absolute calibration coefficients as the current linear model resulted in an overcorrection of the degradation in the SWIR. Investigation for the implementation of a non-linear degradation model to take into account the asymptotic degradation trend is on-going.

The RED band of the three cameras shows a slight increase in responsivity. As the RED band is used as reference band in the DCC calibration parts of the decreasing trend in the DCC results of mainly the BLUE band can be attributed to the increase in RED band. It is currently under investigation why the RED band shows an increase in responsivity.

Due to a forgetfulness in the instrument calibration planning no lunar acquisitions were performed in September 2018.

An increase in the dark currents of the SWIR strips of LEFT and CENTER camera have been observed during the last month. This increase might be linked to an increase in the temperature observed during the last weeks.

During Q4 of 2018 one new bad pixel (i.e. LEFT SWIR1 Pixel id 39 (0-based)) was identified.

# 1.2. Assessment of the radiometric accuracy

## 1.2.1. Absolute radiometric accuracy

The absolute radiometric calibration requirement for PROBA-V specifies a 5 % absolute accuracy. This requirement is assessed through vicarious calibration over Libya-4 desert site and Rayleigh calibration zones.

### 1.2.1.1. Libya-4 desert calibration

***Methodology***

The nominal approach for assessing the absolute radiometric accuracy relies on the comparison between cloud-free TOA reflectance as measured over the Libya-4 desert site by PROBA-V and the modelled TOA reflectance values, following the approach described in [LIT1]. Validation of the approach using various satellite data (i.e. AQUA-MODIS, MERIS, AATSR, PARASOL, SPOT-VGT) has shown that absolute calibration over the Libya-4 desert is achievable with this approach with an accuracy of 3% [LIT1, LIT2].

***Results***

In Figure1, Figure3 and Figure 5 the monthly averaged results ($avg(\rho_{TOA}^{k,ProbaV(Acom)}/\rho_{TOA}^{k,model})$ ) and its standard deviation are given for respectively LEFT, CENTER and RIGHT camera.
The individual area-averaged results are given in Figure2, Figure4 and Figure 6 with a 3 % error bar (as expected uncertainty for an individual result) for respectively VNIR and SWIR strips.

Results are obtained based on the **Collection 1** ICP files.

Since October 2018 a degradation model is no longer applied to the SWIR absolute calibration coefficients as the current linear model resulted in an overcorrection of the degradation in the SWIR.

The RED band of the three cameras shows a slight increase in responsivity over the 5 years in orbit. It is currently under investigation why the RED band shows an increase in responsivity.

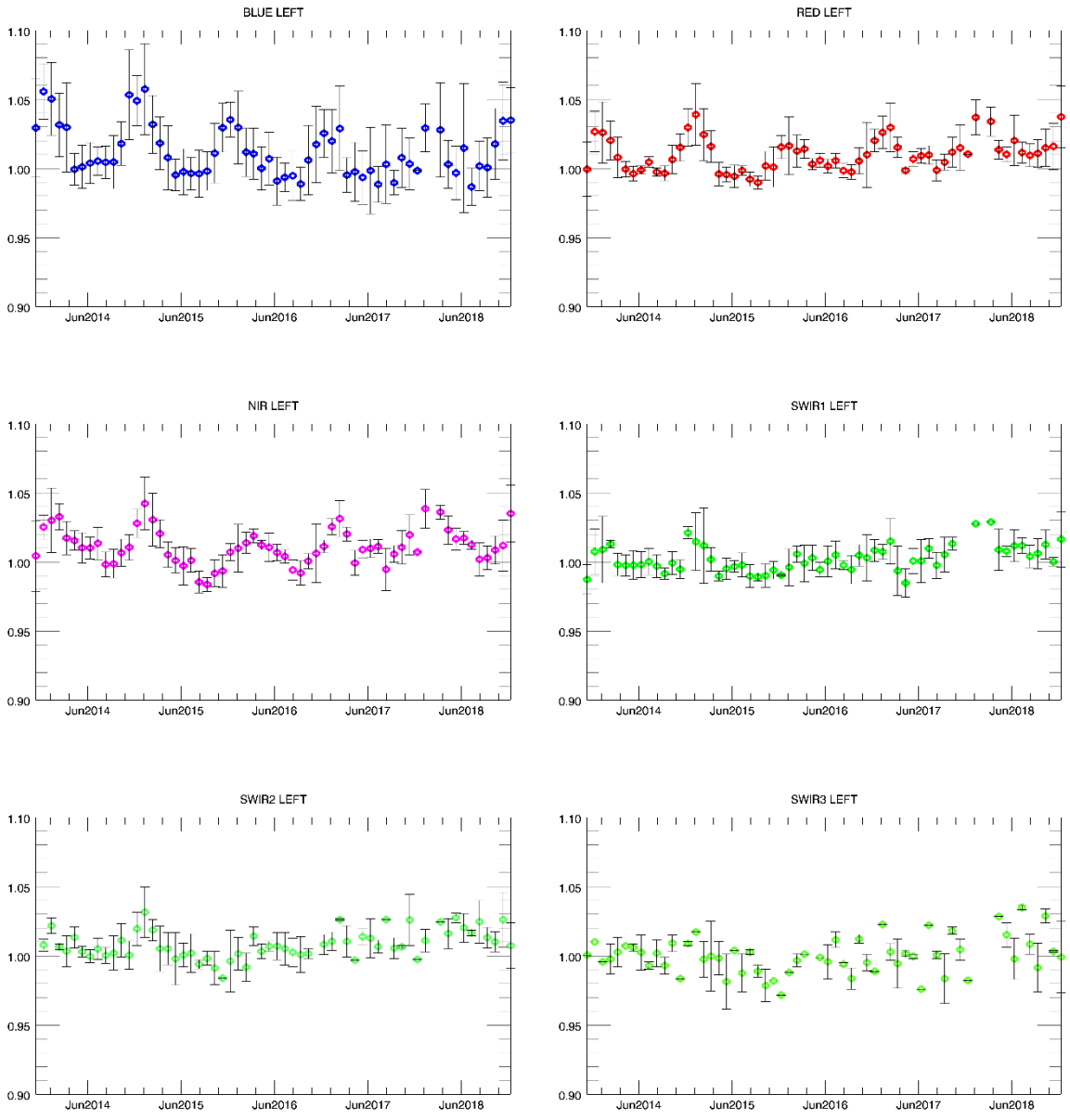



*Figure 1. Libya-4 desert calibration results: LEFT monthly averaged results (Collection 1)*

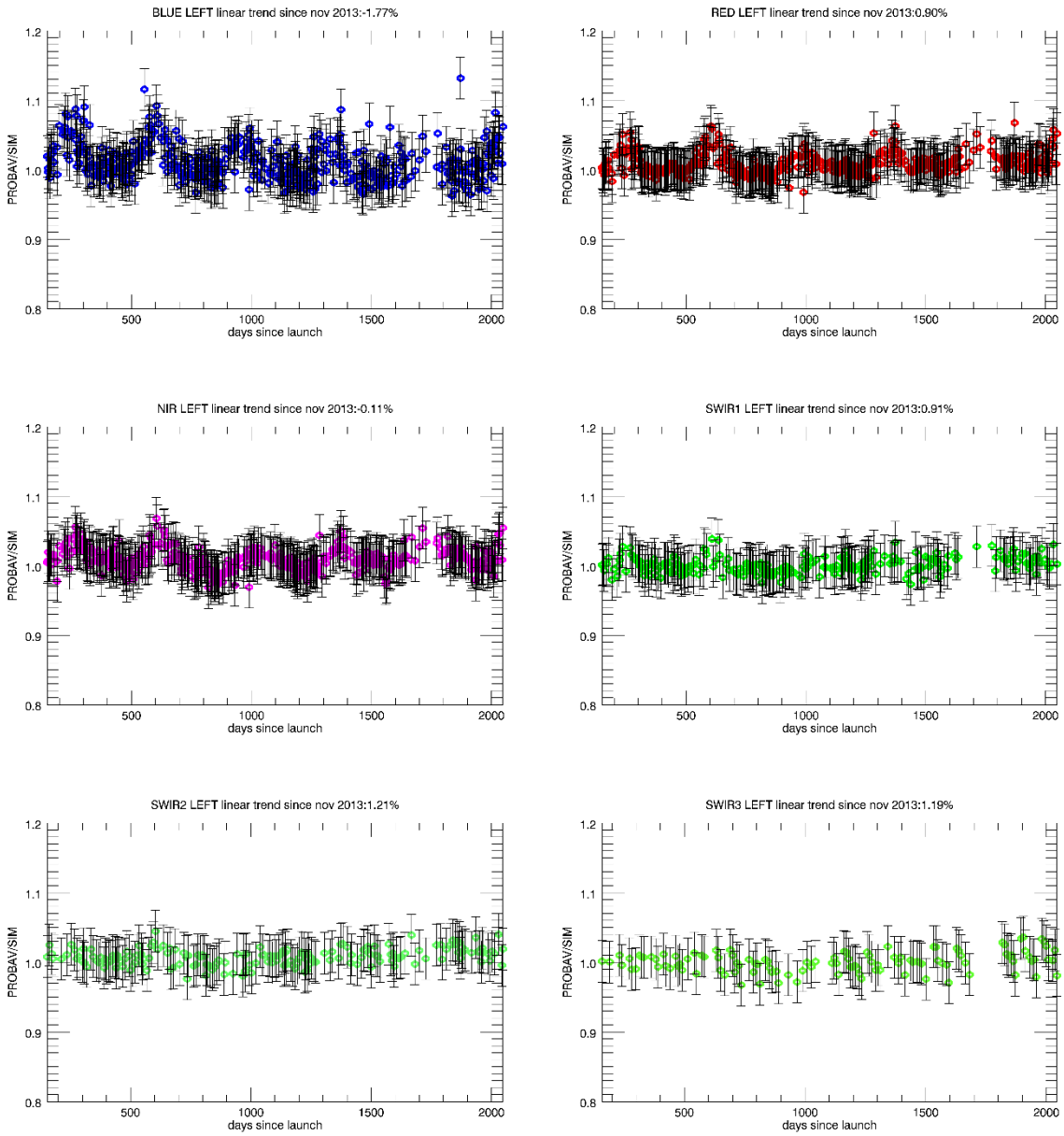



*Figure 2. Libya-4 desert calibration results: LEFT individual results (Collection 1)*

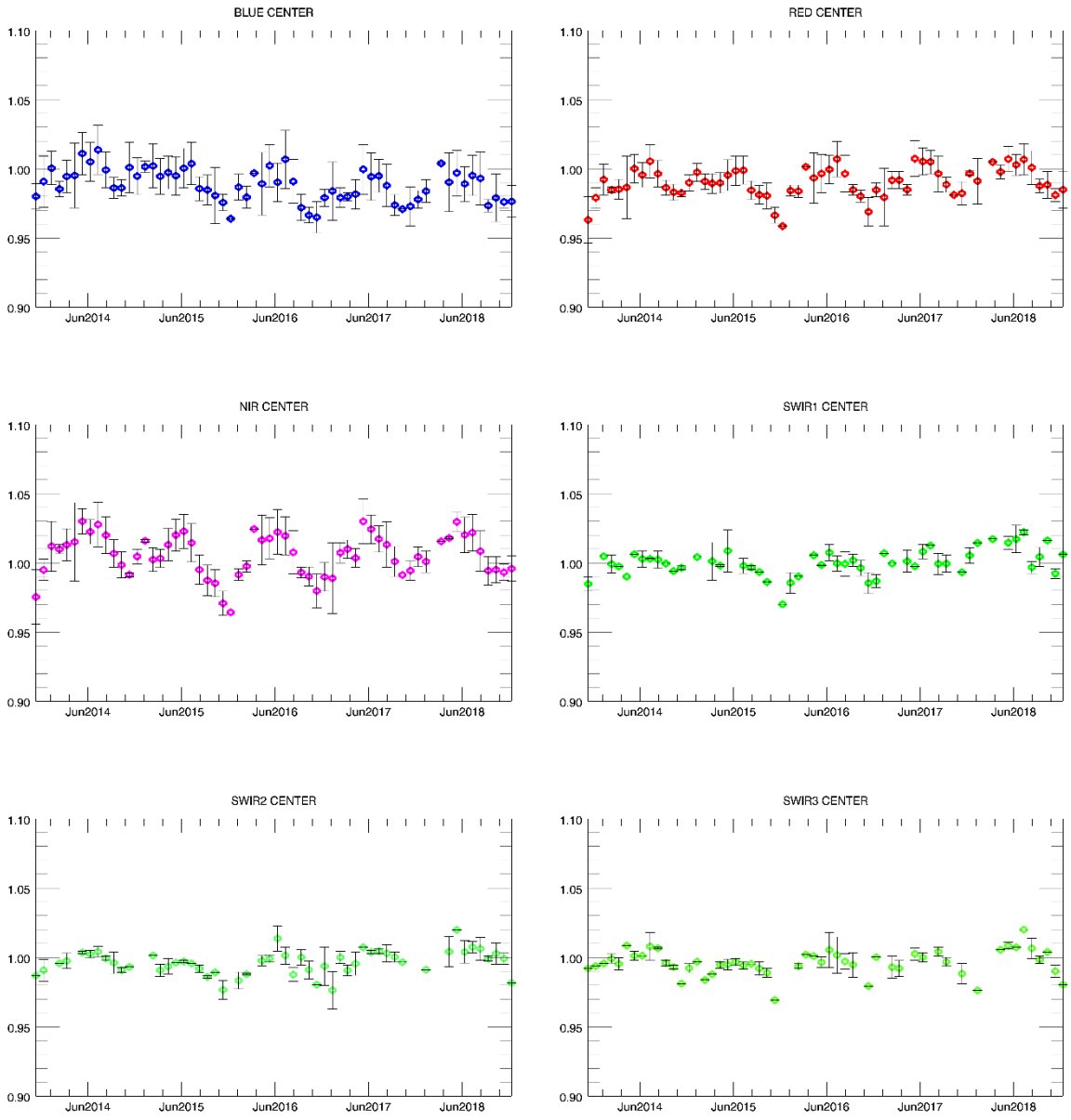



*Figure 3. Libya-4 desert calibration results: CENTER monthly averaged results (Collection 1)*

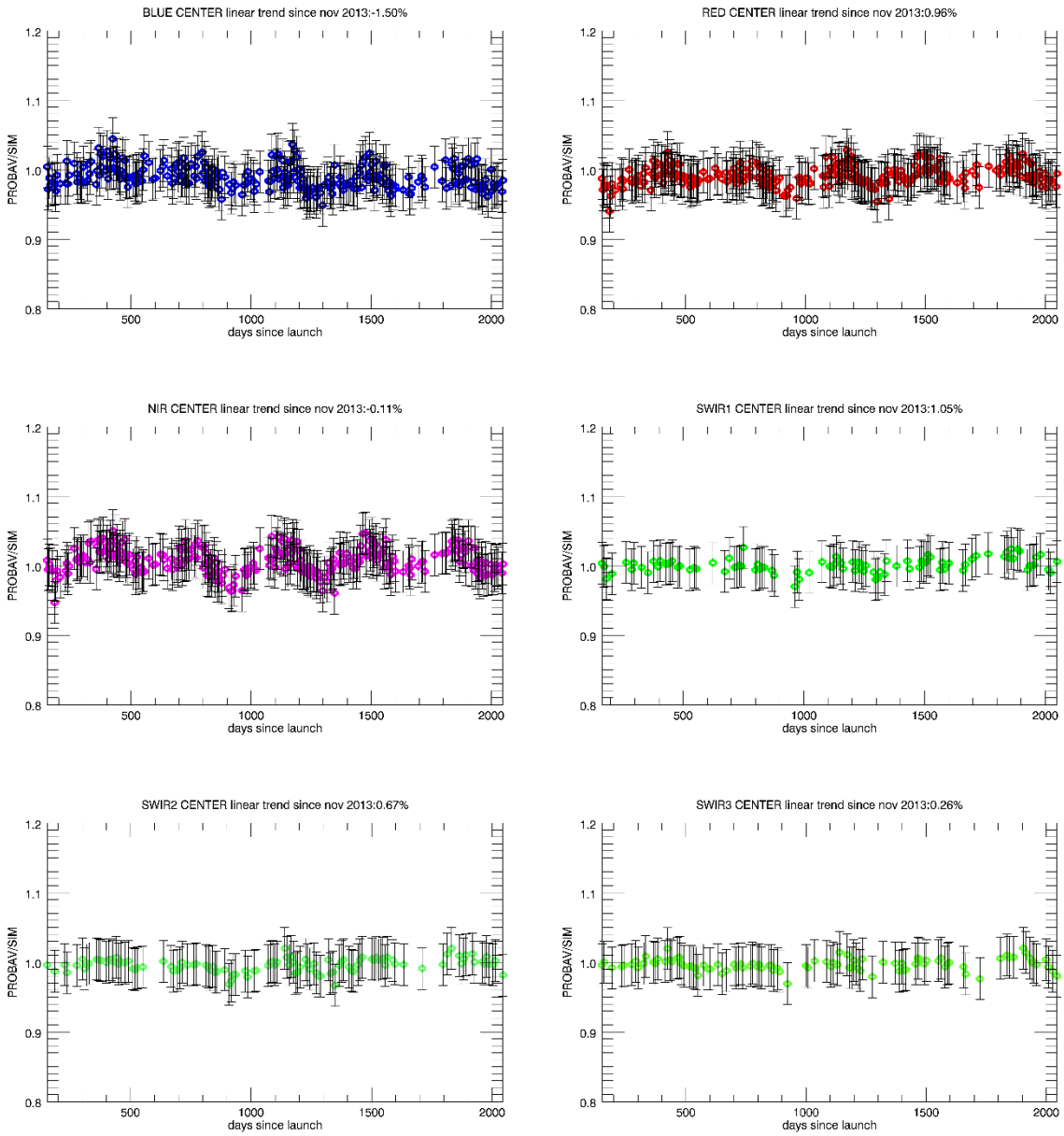



*Figure 4. Libya-4 desert calibration results: CENTER individual results (Collection 1)*

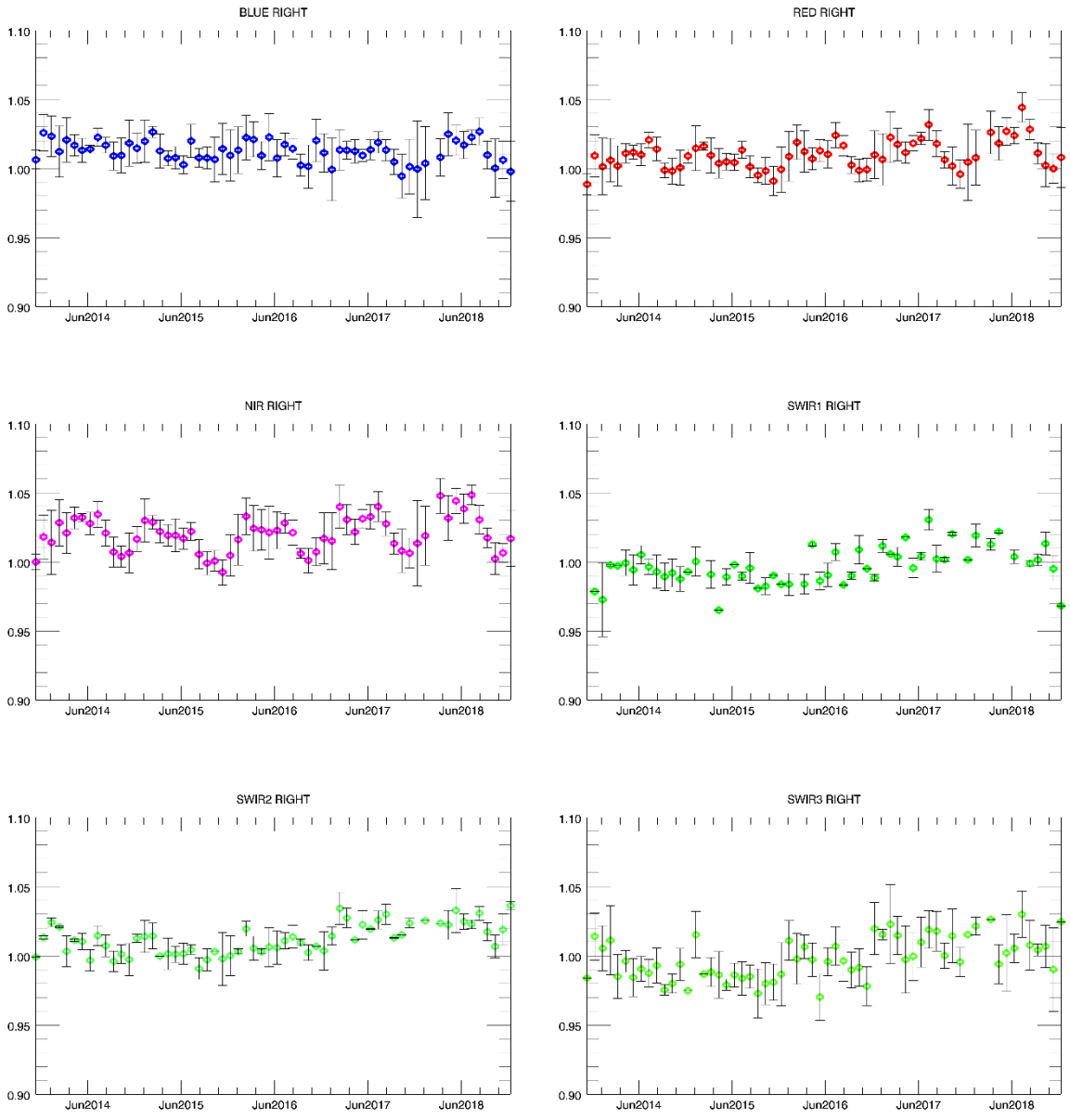



*Figure 5. Libya-4 desert calibration results: RIGHT monthly averaged results (Collection 1)*

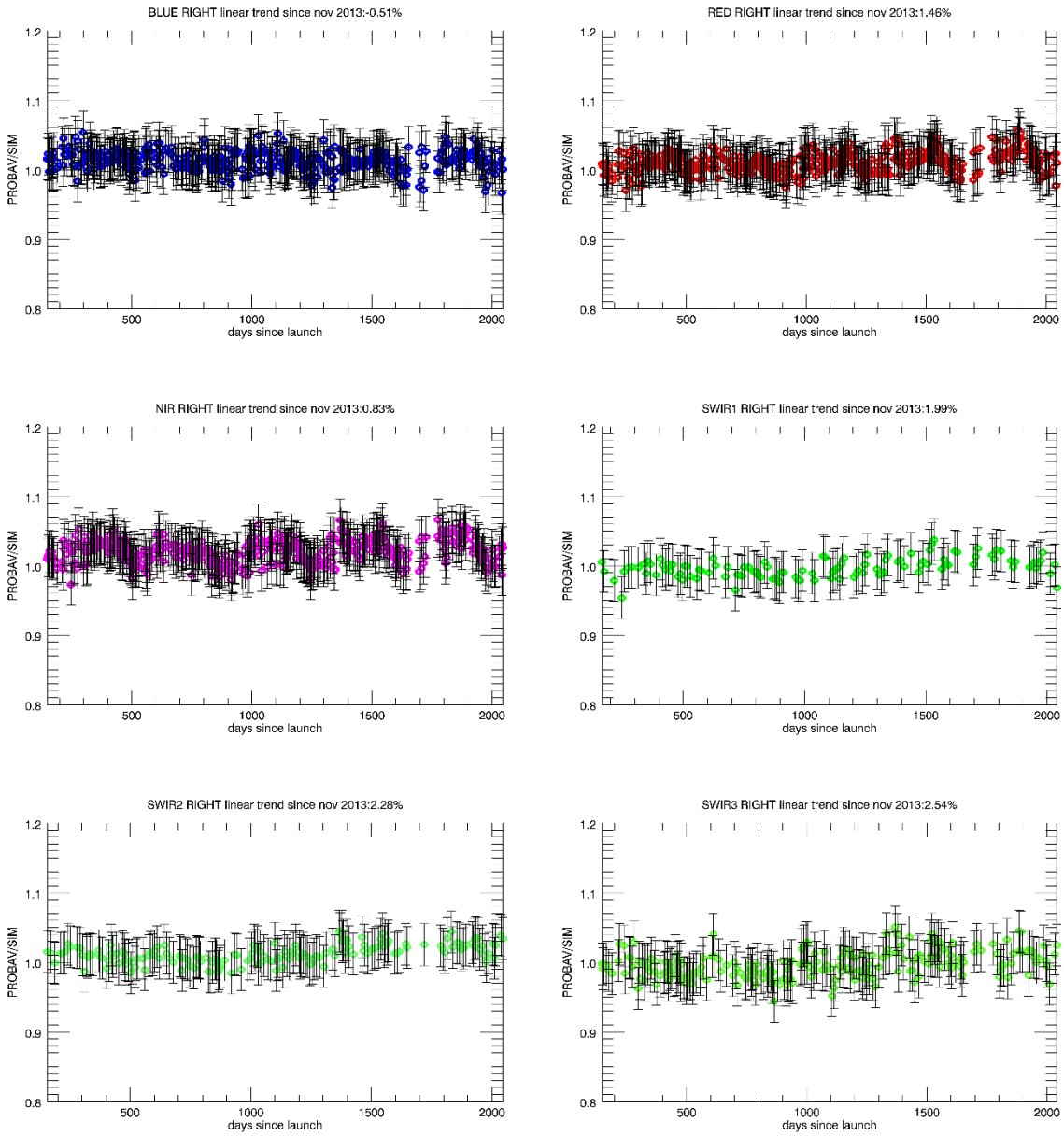



*Figure 6. Libya-4 desert calibration results: RIGHT individual results (Collection 1)*

#### 1.2.1.2. Rayleigh calibration

***Methodology***

The Rayleigh calibration approach is an absolute calibration method for BLUE and RED bands. The primary assumption of the approach is that the ocean does not contribute to the Top-Of-Atmosphere (TOA) signal in the NIR. The contribution of aerosol scattering is derived from the ***NIR reference band*** where molecular scattering is negligible. The aerosol content estimated from the NIR band is then transferred to the BLUE and RED band to model the TOA radiance with a radiative transfer code. The simulated radiance values are then compared with the measured values.

***Results***

The scene averaged Rayleigh results ($(\rho_{TOA}^{k,ProbaV(Acom)}/\rho_{TOA}^{k,model})$ ) (with a 4 % error bar as rough indication of uncertainty of one individual result) obtained since January 2014 for LEFT, CENTER and RIGHT camera are given in respectively Figure 7, Figure 8 and Figure 9.

Results are obtained using the **Collection 1 ICP** files.

No significant trend is visible in the Rayleigh calibration results.

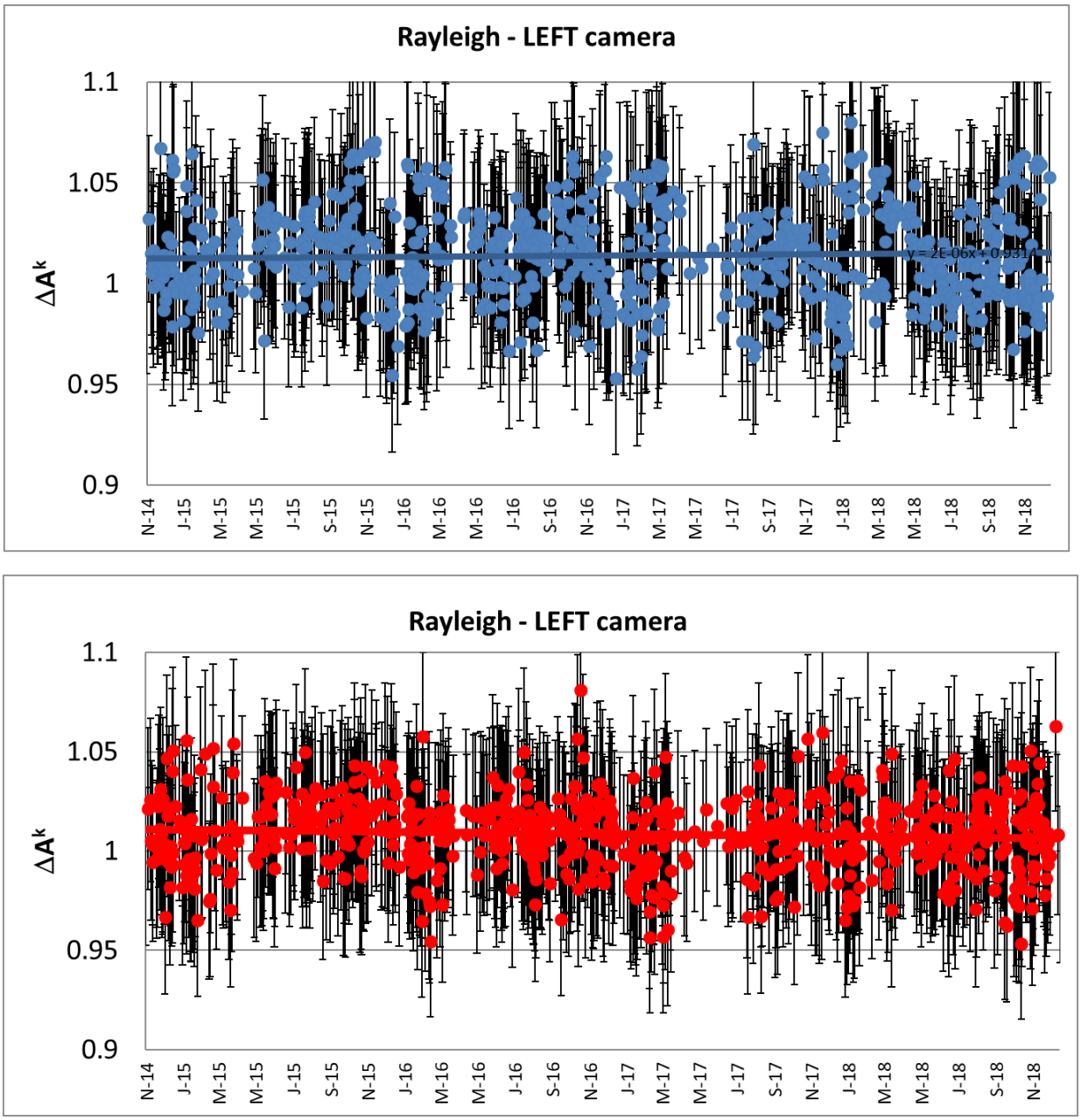



*Figure 7. Rayleigh absolute calibration results: LEFT camera (Collection 1)*

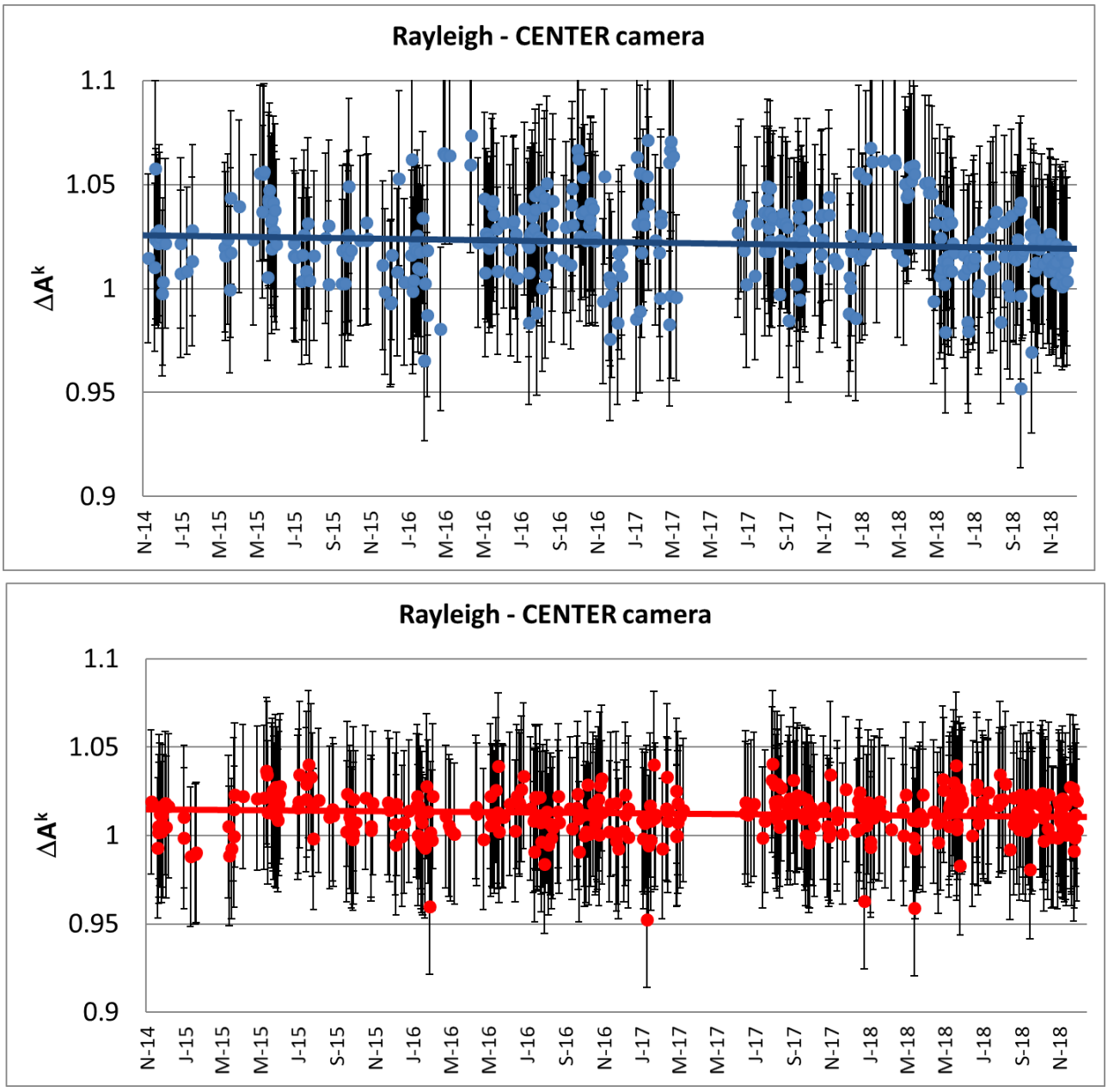
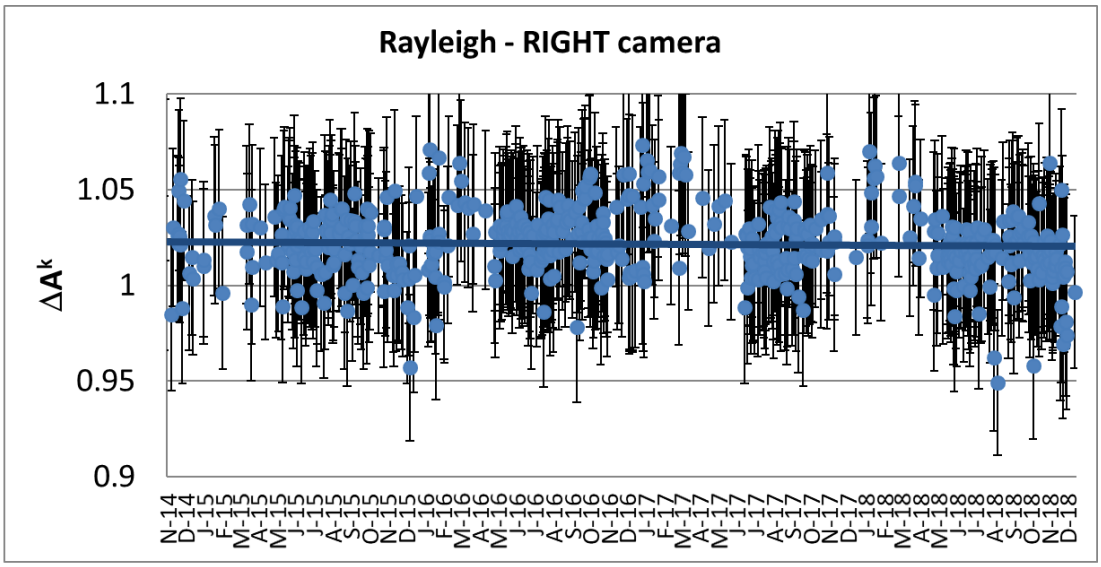



*Figure 8. Rayleigh absolute calibration results: CENTER camera (Collection 1)*



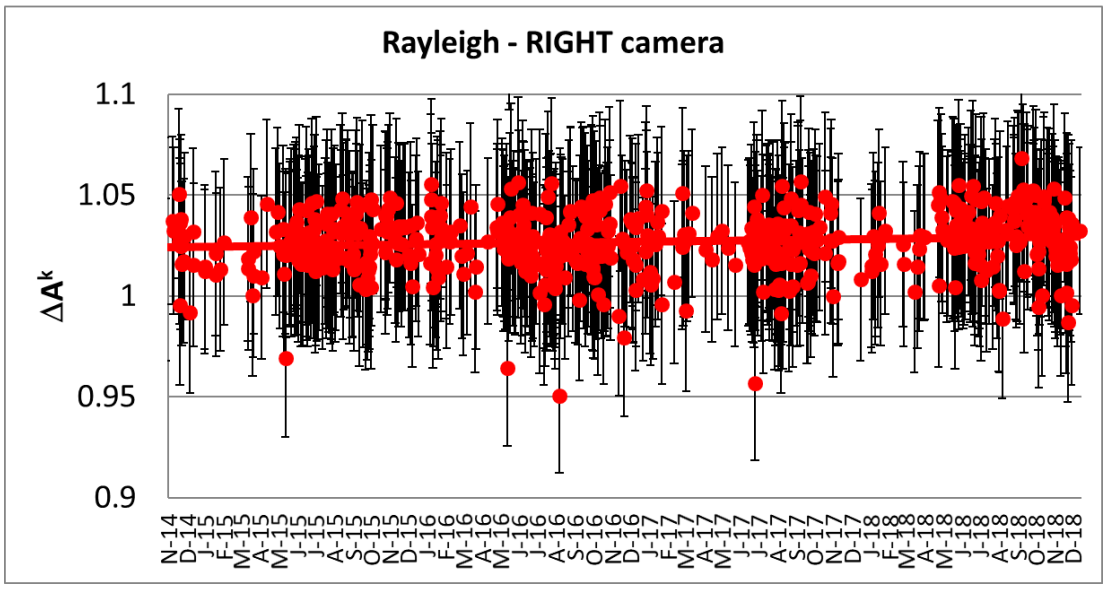




*Figure 9. Rayleigh absolute calibration results: RIGHT camera (Collection 1)*

## 1.2.2. Inter-band radiometric accuracy

The inter-band radiometric calibration requirement for PROBA-V specifies a 3 % inter-band accuracy. This requirement is assessed through vicarious calibration over deep convective clouds.

### 1.2.2.1. Calibration over deep convective clouds (DCC)

***Methodology***

The DCC approach is an inter-band calibration method. It makes use of bright, thick, high altitude, convective clouds over oceanic sites. Their reflective properties are spectrally flat in visible and near-infrared and the only contributions to the observed signal are from the cloud reflectance, molecular scattering and ozone absorption which can be modelled with a radiative transfer code.
The cloud reflectance in the non-absorbing VNIR bands is mainly sensitive to the cloud optical thickness. The DCC method uses the TOA reflectance in the 'reference' RED band to estimate cloud optical thickness assuming a fixed ice particle model. The derived cloud optical thickness is then used to model using a radiative transfer code the TOA reflectance for the BLUE and NIR band.

The method is not suited for the SWIR band as clouds are no longer spectrally uniform in this spectral region.

***Results***

The DCC inter-band calibration is defined by reference to the used RED reference band. The average DCC inter-band calibration result per month (from March 2015 to December 2018) is given in Figure 10 for all cameras using the **collection 1 ICP files**.

The DCC calibration results show for the current month (i.e. December 2018) a sudden increase in the NIR band results. As these results are only based on two scenes, it is at the moment unclear if this is related to the PROBA-V instrument itself or due to scene specific issues. The trend will be closely followed and compared with lunar and desert observations.

As the RED band is used as reference band in the DCC calibration parts of the decreasing trend in the DCC results of mainly the BLUE band can be attributed to the increase in RED band.

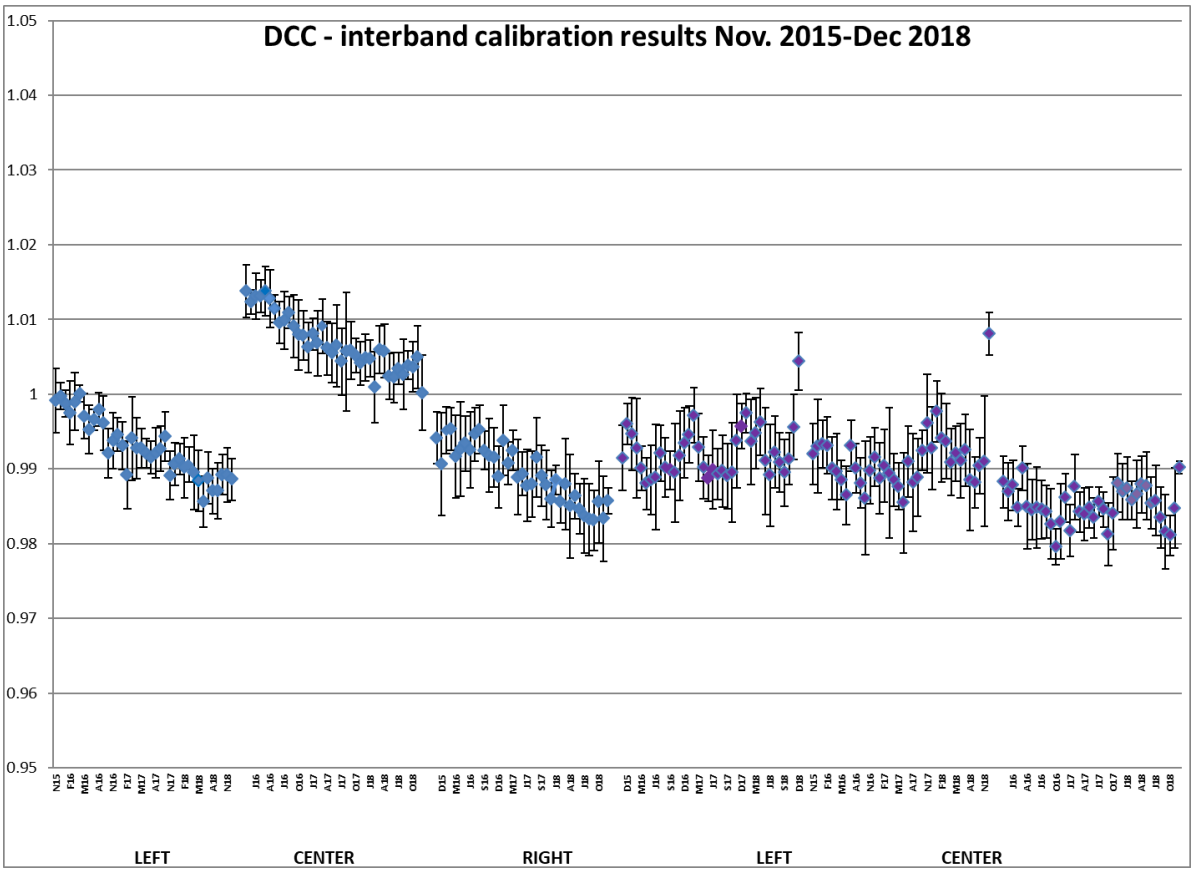



*Figure 10. DCC inter-band calibration results: LEFT, CENTER and RIGHT camera*

## 1.2.3. PROBA-V Multi-temporal radiometric accuracy

### 1.2.3.1. Degradation model

Since October 2018 a degradation model is no longer applied to the SWIR absolute calibration coefficients as the current linear model resulted in an overcorrection of the degradation in the SWIR. Investigation for the implementation of a non-linear degradation model to take into account the asymptotic degradation trend is on-going.

In Table 1 the applied degradation model correction is given. This linear degration model is being applied for collection 1 since start of the operational phase (i.e. October 2013). A re-evaluation of the coefficients of the SWIR degradation model was performed in summer 2017. Since Jan 2018 a degradation model is no longer applied to the RIGHT SWIR strips. From October 2018 onwards, absolute calibration coefficients for the SWIR strips are not updated.

*Table 1 SWIR degradation model: applied linear trend/month*

| | **Degradation model ICP** | | | |
|---|---|---|---|---|
| | Start- aug 2017 | Sept 2017-Dec 2018 | Jan 2018-Sept 2018 | Oct 2018-.. |
| SWIR1 LEFT | -0.087 | -0.087 | -0.087 | NA |
| SWIR2 LEFT | -0.104 | -0.104 | -0.104 | NA |
| SWIR3 LEFT | -0.097 | -0.097 | -0.097 | NA |
| SWIR1 CENTER | -0.093 | -0.093 | -0.093 | NA |
| SWIR2 CENTER | -0.092 | -0.092 | -0.092 | NA |
| SWIR3 CENTER | -0.086 | -0.086 | -0.086 | NA |
| SWIR1 RIGHT | -0.106 | -0.077 | NA | NA |
| SWIR2 RIGHT | -0.143 | -0.122 | NA | NA |
| SWIR3 RIGHT | -0.122 | -0.078 | NA | NA |

A degradation model is used to update the absolute calibration coefficients of the LEFT and RIGHT BLUE since May 2017. A re-evaluation of the coefficients of the degradation model was performed in summer 2017. Since then no changes have been made to the model. In Table 2 the coefficients are given.

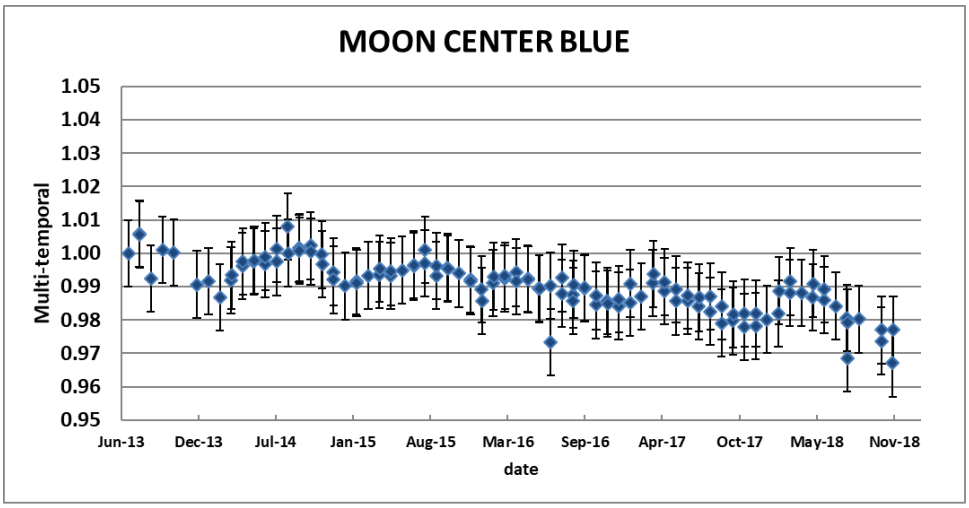
*Table 2 Degradation model BLUE LEFT and CENTER camera: applied linear trend/month*

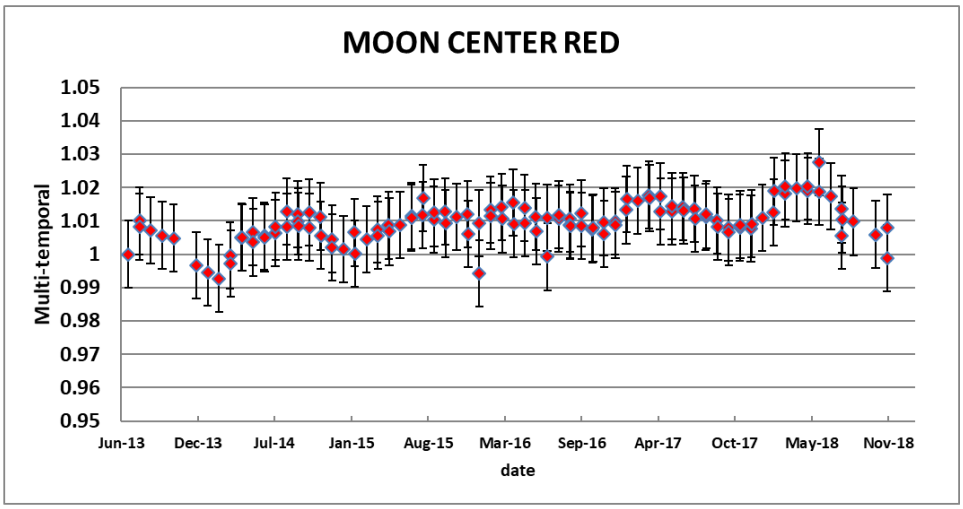
| | Linear trend/month (%) | |
|---|---|---|
| | Degradation model ICP | Degradation model ICP |
| STRIP | may 2017-aug 2017 | since sept 2017 |
| BLUE LEFT | -0.028 | -0.036 |
| BLUE CENTER | -0.011 | -0.034 |

#### 1.2.3.2. Lunar calibration

The Lunar calibration results for the VNIR CENTER camera bands, normalised to June 2013, are given in Figure 11. The results are given based on the **collection 1 ICP** files.

Similarly as in the Libya-4 CENTER RED results an increase in responsivity is observed in the lunar CENTER RED results and a degradation in the BLUE calibration results, whereas the results of the NIR strip seems to stable over time.



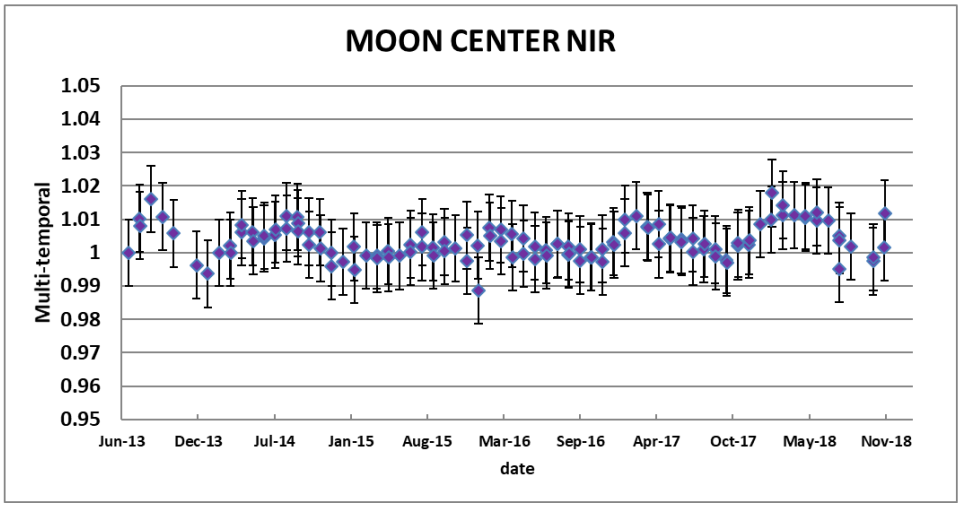




*Figure 11. Lunar Calibration results CENTER camera normalised to June 2013 (collection 1 ICP files)*

#### 1.2.3.3. Libya-4 VS Moon

As mentioned in previous report degradation trends observed in the Lunar calibration results for the center SWIR2 strip are less significant than these observed in the desert calibration results. In the frame of the ESA's 'Lunar Irradiance Measurements of the Moon' project VITO is working on an improved lunar model. A reprocessing of the PROBA-V lunar calibration results based on the improved model is foreseen for the near future. It is expected that this will give us a better insight in the actual degradation trend.

# 1.3. Dark current

## 1.3.1. Methodology

- Monthly difference plots :
  - All dark current results obtained during a period of one month for observations performed with a long integration time are averaged per pixel. This gives for each pixel the monthly averaged dark current, expressed **in LSB/s**, and its standard deviation.
  - The dark current results and its standard deviation expressed in LSB/s are converted to **LSB** using a maximum Integration Time for nominal acquisitions. For VNIR strips **0.006s** is used. For SWIR strips **0.02s.**
  - The differences between months (i.e. Month3-Month2, Month2-Month1) are calculated. This is done for both the dark current and the stdev. Differences are visualized in plots in blue the dark current difference in LSB is plotted, in red the standard deviation difference. This latter is an indicator of changes in the dark current noise between months.

As mentioned in the previous quarterly report (IQR#005) the integration time used for the SWIR dark current acquisitions has been decreased from 3s to 0.2 s since 2015.

## 1.3.2. VNIR results

Monthly difference plots for VNIR dark currents are given in

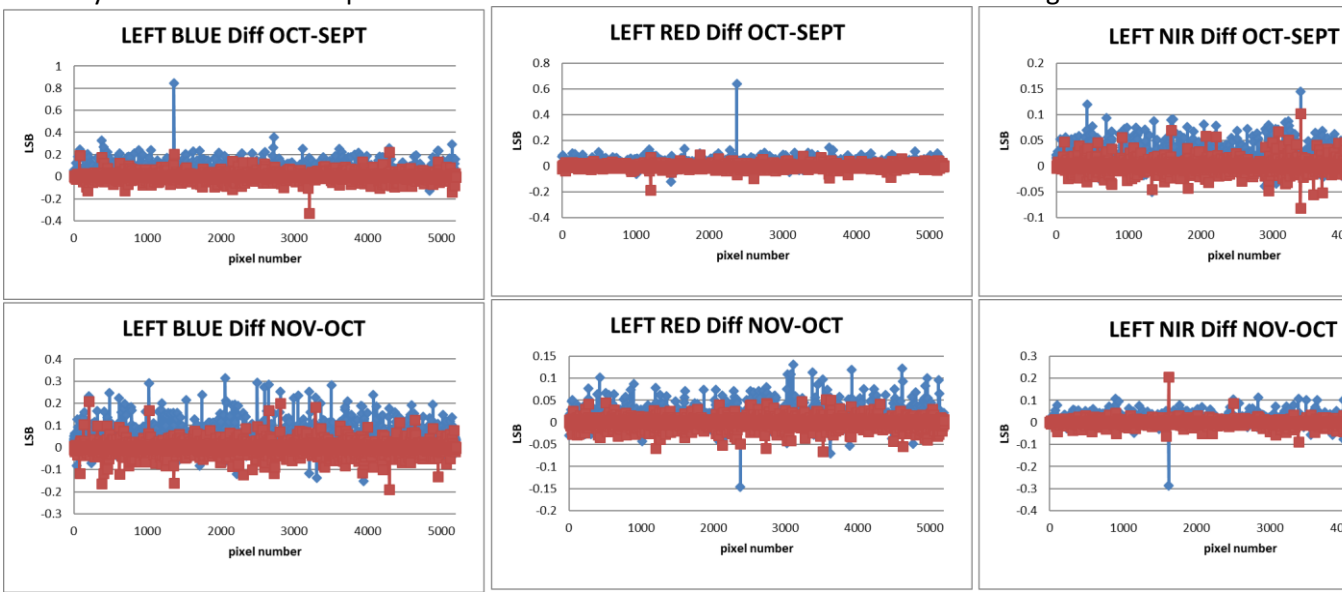


Figure 12,

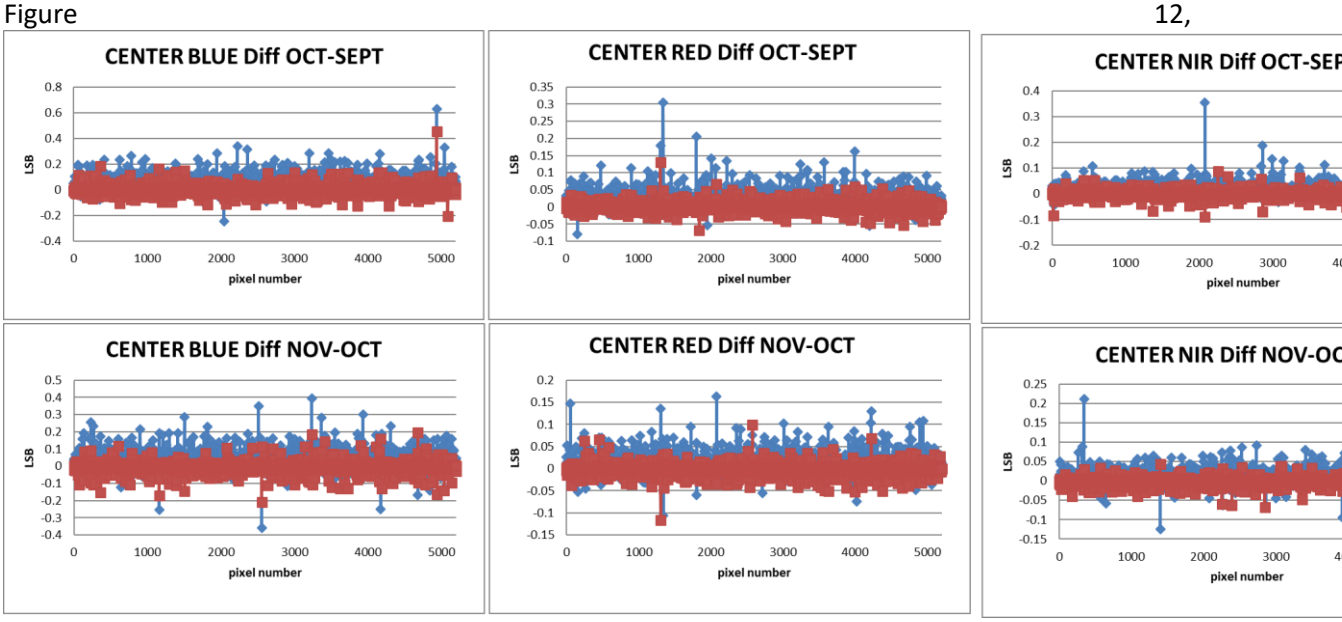



*Figure 13* and Figure 14
for respectively LEFT, CENTER and RIGHT camera.

Dark current differences for the VNIR bands are well below 1 DN.

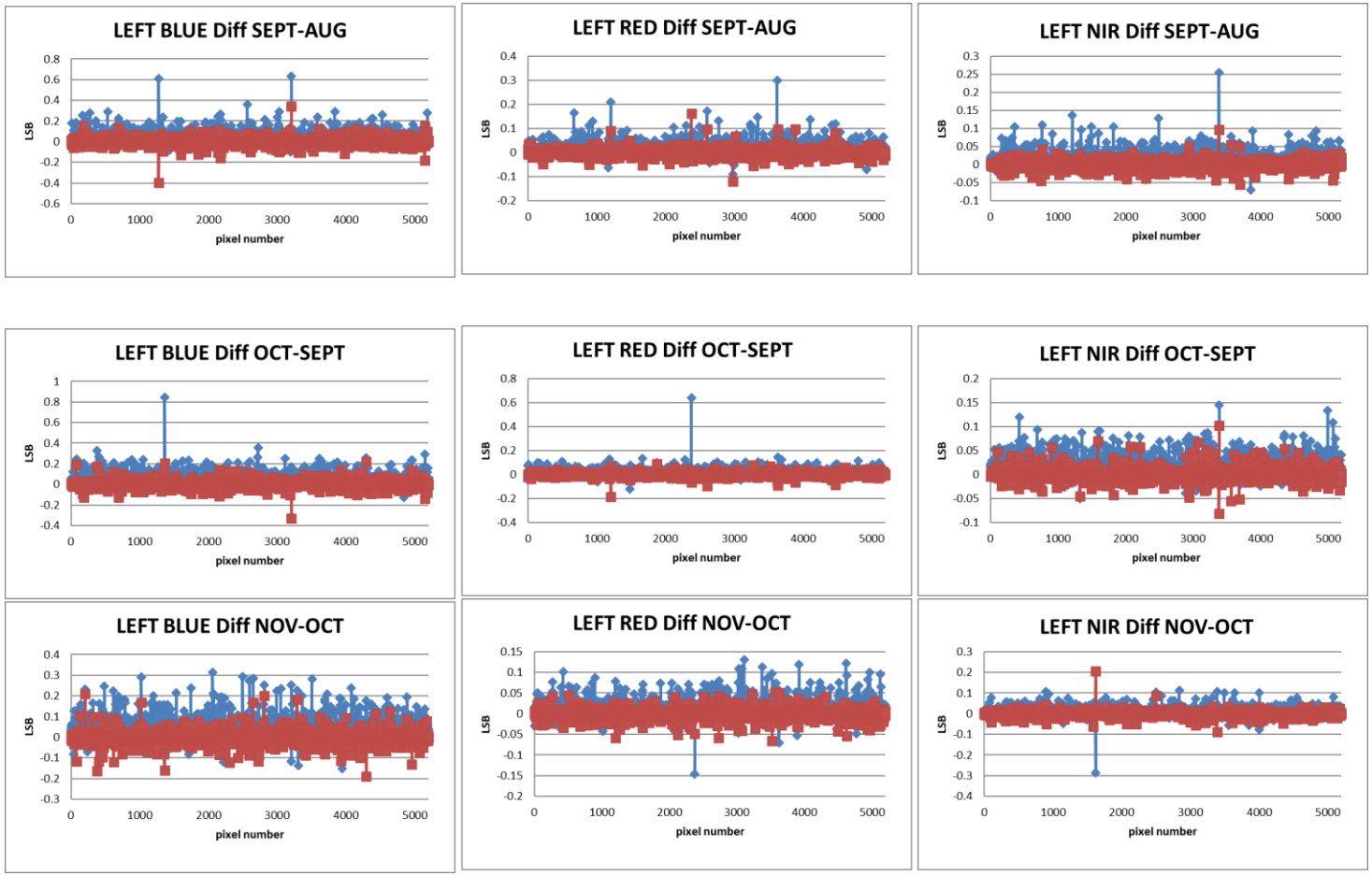



*Figure 12. LEFT camera VNIR: Monthly difference ( AUG NOV 2018) in dark current (Blue) and standard deviation (Red) of the monthly averaged results.*

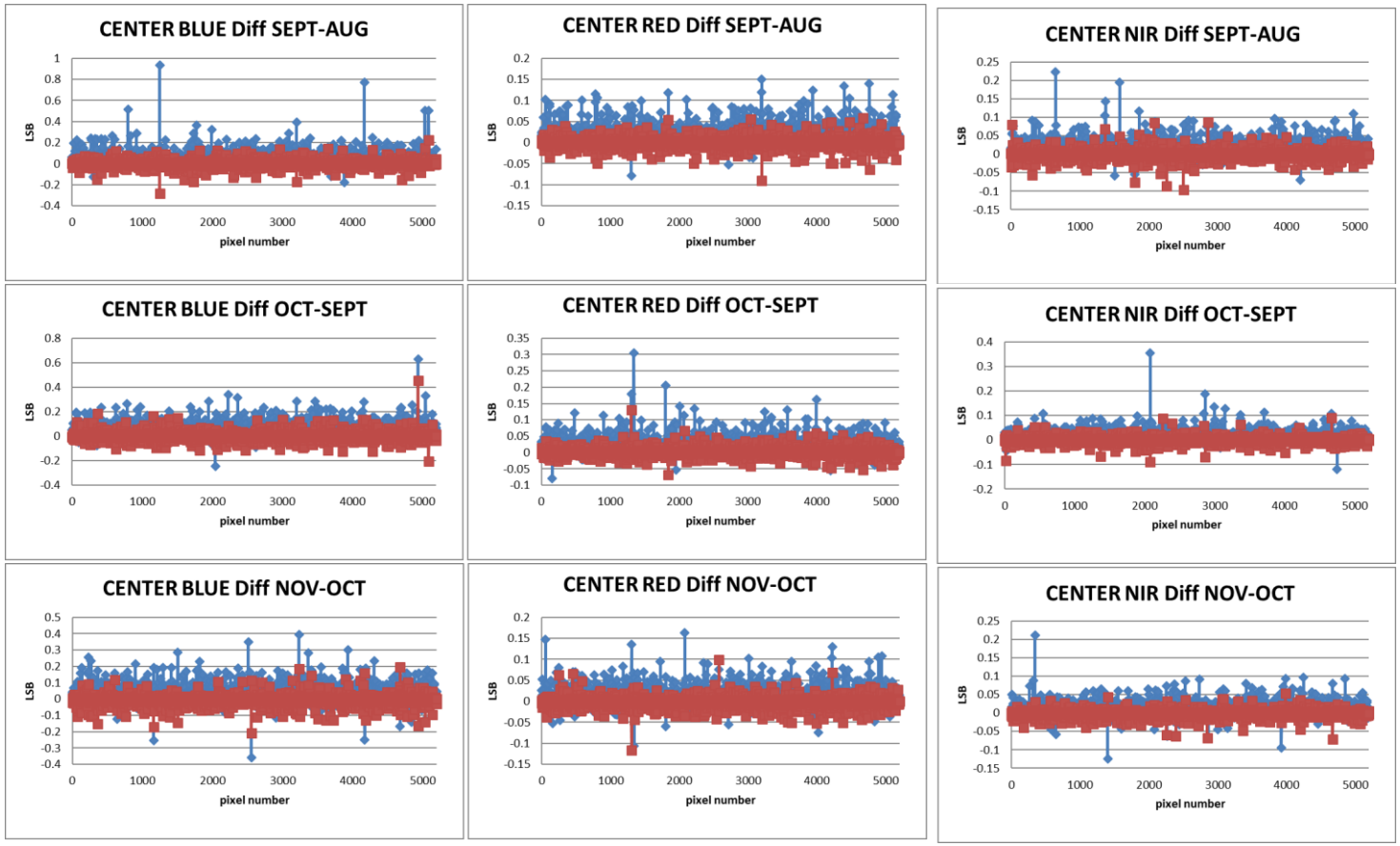



*Figure 13. CENTER camera VNIR: Monthly difference (* AUG- NOV 2018*) in dark current (Blue) and standard deviation (Red) of the monthly averaged results.*

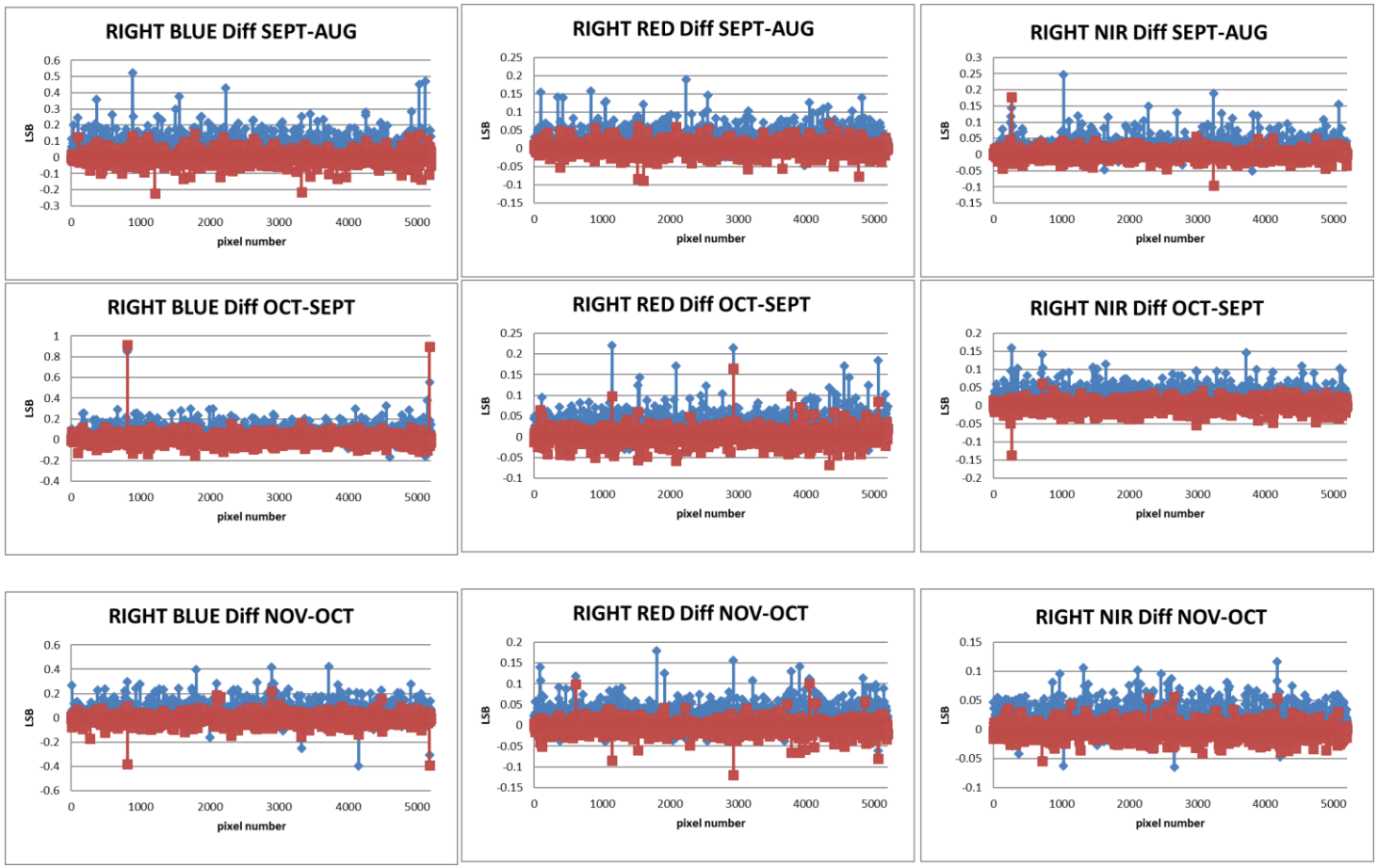



*Figure 14. RIGHT camera VNIR: Monthly difference (*AUG NOV2018*) in dark current (Blue) and standard deviation (Red) of the monthly averaged results.*

## 1.3.3. SWIR results

Monthly difference plots for SWIR dark currents are given in Figure 15, Figure 16 and

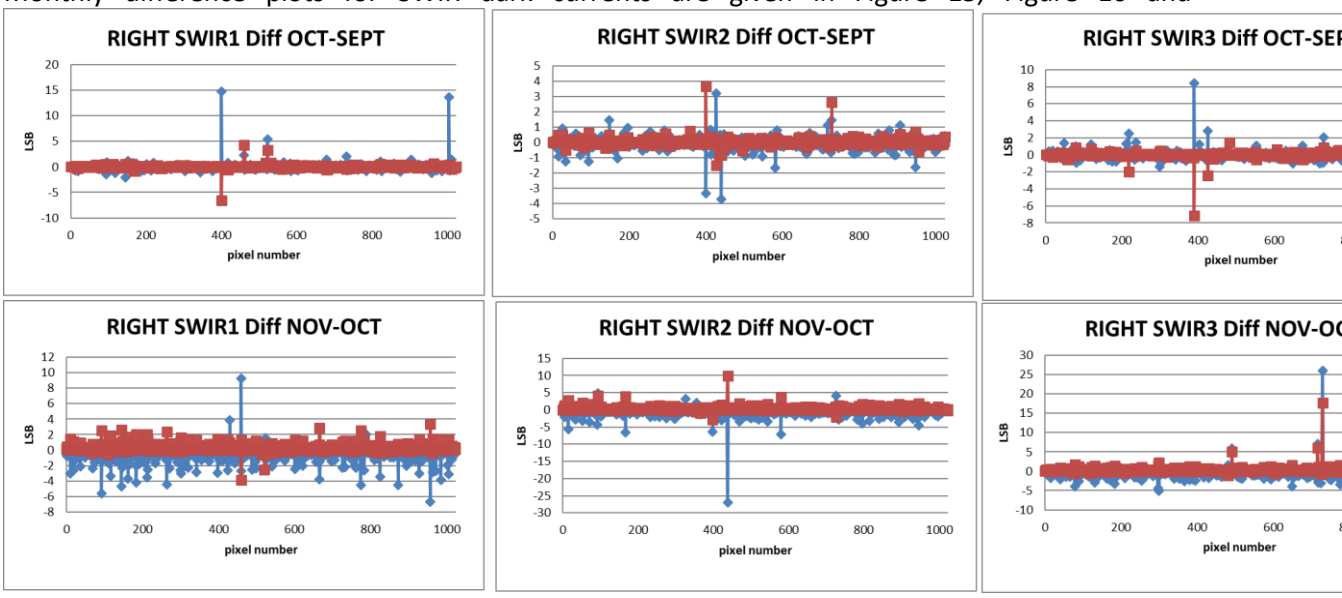



*Figure 17* for respectively LEFT, CENTER and RIGHT camera.

A dark current outlier analysis is performed for pixels having for at least one month a dark current expressed in LSB larger than the DC THRESHOLD. This DC THRESHOLD is set to 4 LSB. For those pixels the following dark current pixel statuses are given:

- Both monthly differences > 4 LSB ? **Quality is "H DC BAD"**
- One monthly difference > 4 LSB ? **Quality is "H DC NOK"**.
- Both monthly differences < 4 LSB ? **Quality is "H DC OK"**

In Table 3,

| JUL-AUG-SEPT | | | | | | AUG-SEPT-OCT | | | | | | SEPT-OCT-NOV | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SWIR1 | | SWIR2 | | SWIR3 | | SWIR1 | | SWIR2 | | SWIR3 | | SWIR1 | | SWIR2 | | SWIR3 | |
| 109 | H DC NOK | 208 | H DC BAD | 729 | H DC BAD | 69 | H DC NOK | 197 | H DC NOK | 354 | H DC BAD | 161 | H DC BAD | 831 | H DC BAD | 30 | H DC BAD |
| 305 | H DC NOK | 197 | H DC NOK | 354 | H DC NOK | 161 | H DC NOK | 208 | H DC NOK | 30 | H DC NOK | 545 | H DC BAD | 134 | H DC NOK | 99 | H DC BAD |
| 358 | H DC NOK | 648 | H DC NOK | 504 | H DC NOK | 305 | H DC NOK | 428 | H DC NOK | 99 | H DC NOK | 819 | H DC BAD | 295 | H DC NOK | 131 | H DC BAD |
| 819 | H DC NOK | 896 | H DC NOK | 163pixels | H DC OK | 337 | H DC NOK | 433 | H DC NOK | 131 | H DC NOK | 1001 | H DC BAD | 428 | H DC NOK | 354 | H DC BAD |
| 908 | H DC NOK | 286pixels | H DC OK | | | 358 | H DC NOK | 831 | H DC NOK | 448 | H DC NOK | 1021 | H DC BAD | 433 | H DC NOK | 579 | H DC BAD |
| 916 | H DC NOK | | | | | 545 | H DC NOK | 896 | H DC NOK | 513 | H DC NOK | 18 | H DC NOK | 687 | H DC NOK | 890 | H DC BAD |
| 241pixels | H DC OK | | | | | 819 | H DC NOK | 288pixels | H DC OK | 579 | H DC NOK | 69 | H DC NOK | 900 | H DC NOK | 994 | H DC BAD |
| | | | | | | 1001 | H DC NOK | | | 729 | H DC NOK | 77 | H DC NOK | 941 | H DC NOK | 152 | H DC NOK |
| | | | | | | 1021 | H DC NOK | | | 890 | H DC NOK | 133 | H DC NOK | 286pixels | H DC OK | 266 | H DC NOK |
| | | | | | | 238pixels | H DC OK | | | 952 | H DC NOK | 165 | H DC NOK | | | 272 | H DC NOK |
| | | | | | | | | | | 994 | H DC NOK | 337 | H DC NOK | | | 364 | H DC NOK |
| | | | | | | | | | | 154pixels | H DC OK | 419 | H DC NOK | | | 397 | H DC NOK |
| | | | | | | | | | | | | 547 | H DC NOK | | | 432 | H DC NOK |
| | | | | | | | | | | | | 641 | H DC NOK | | | 448 | H DC NOK |
| | | | | | | | | | | | | 792 | H DC NOK | | | 476 | H DC NOK |
| | | | | | | | | | | | | 232pixels | H DC OK | | | 504 | H DC NOK |
| | | | | | | | | | | | | | | | | 513 | H DC NOK |
| | | | | | | | | | | | | | | | | 640 | H DC NOK |
| | | | | | | | | | | | | | | | | 682 | H DC NOK |
| | | | | | | | | | | | | | | | | 697 | H DC NOK |
| | | | | | | | | | | | | | | | | 716 | H DC NOK |
| | | | | | | | | | | | | | | | | 729 | H DC NOK |
| | | | | | | | | | | | | | | | | 763 | H DC NOK |
| | | | | | | | | | | | | | | | | 804 | H DC NOK |
| | | | | | | | | | | | | | | | | 868 | H DC NOK |
| | | | | | | | | | | | | | | | | 917 | H DC NOK |
| | | | | | | | | | | | | | | | | 952 | H DC NOK |
| | | | | | | | | | | | | | | | | 957 | H DC NOK |
| | | | | | | | | | | | | | | | | 1005 | H DC NOK |
| | | | | | | | | | | | | | | | | 135pixels | H DC OK |

*Table 4* and *Table 5* the resulting SWIR dark current status during the last 3 months is reported for respectively LEFT, CENTER and RIGHT camera.

An increase in the dark currents of the SWIR strips of LEFT and CENTER camera have been observed during last month. This increase might be linked to an increase in the temperature observed during the last weeks.

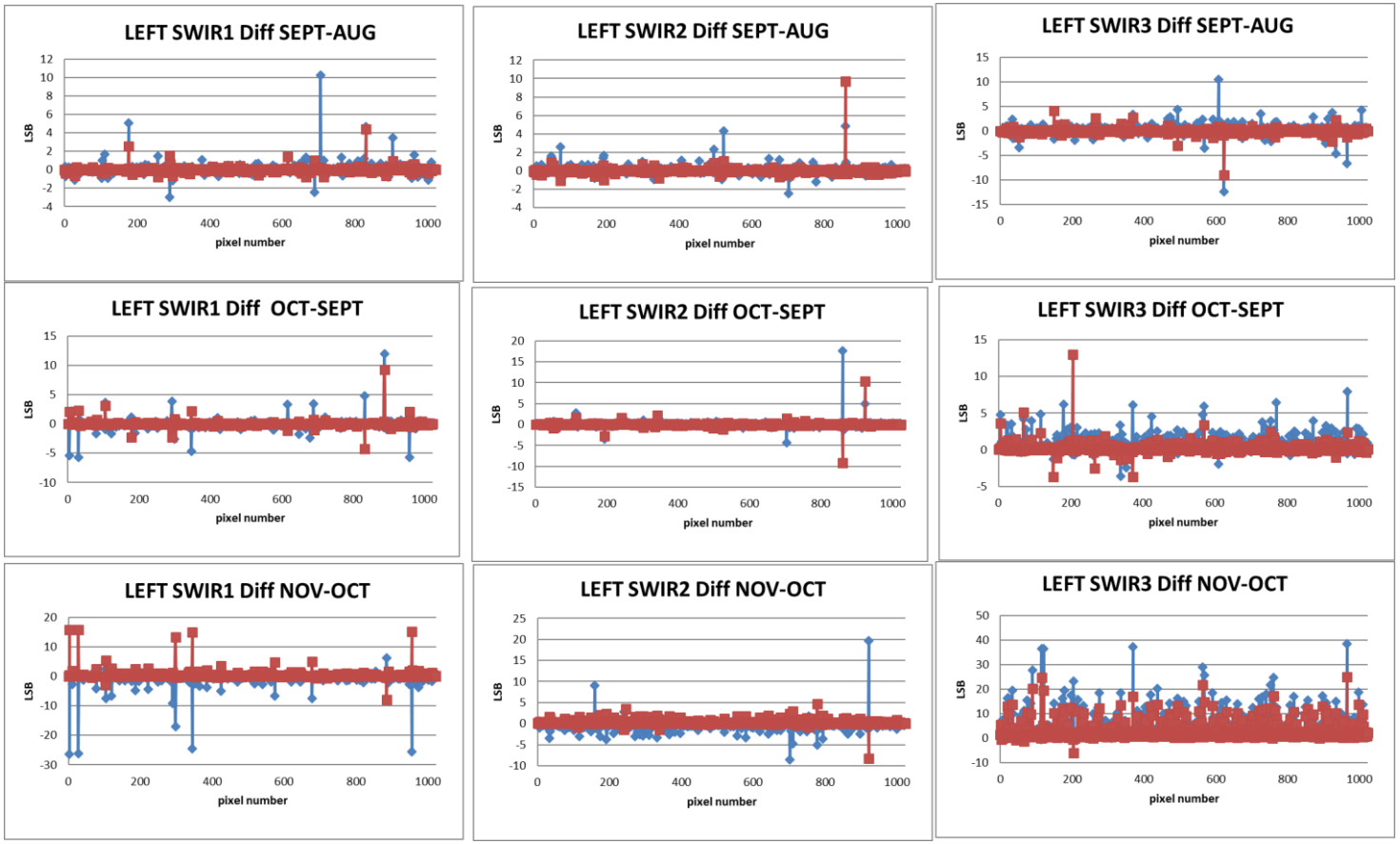



*Figure 15. LEFT camera SWIR: Monthly difference ( AUG NOV 2018) in dark current (Blue) and standard deviation (Red) of the monthly averaged results.*

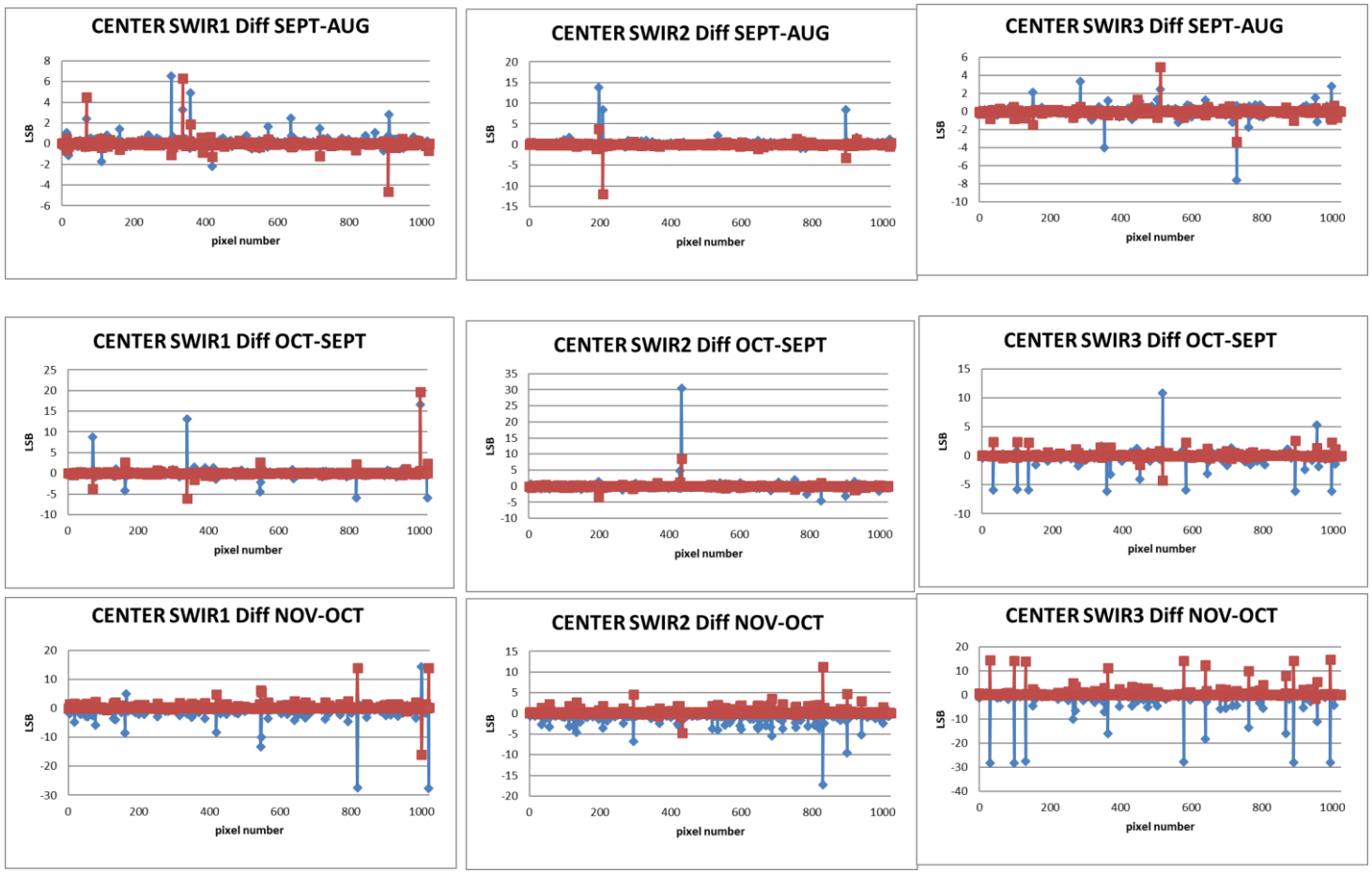



*Figure 16. CENTER camera SWIR: Monthly difference ( AUG NOV 2018) in dark current (Blue) and standard deviation (Red) of the monthly averaged results.*

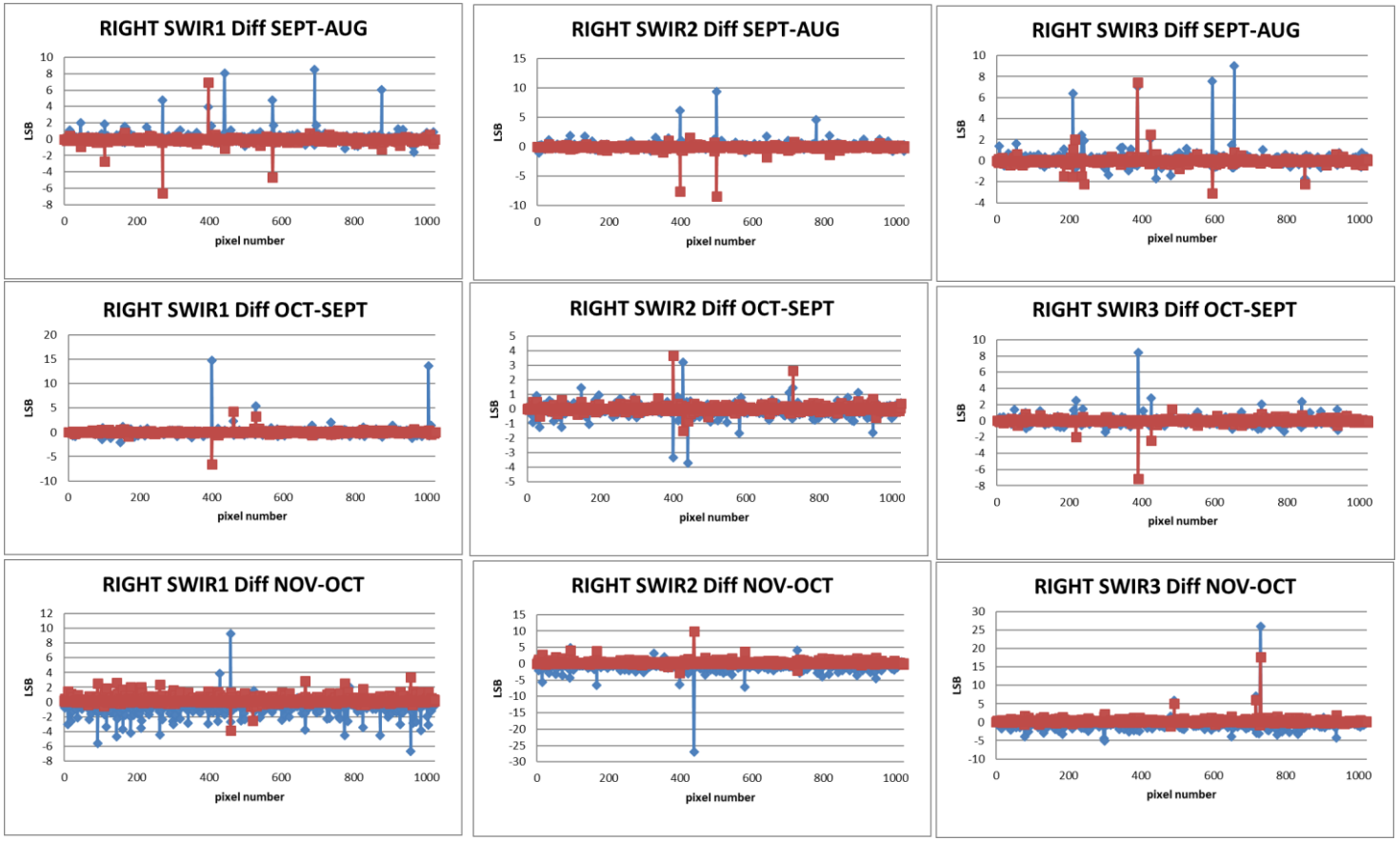



*Figure 17. RIGHT camera SWIR: Monthly difference ( AUG NOV 2018) in dark current (Blue) and standard deviation (Red) of the monthly averaged results.*

| JULY-AUG-SEPT | | | | | | AUG-SEPT-OCT | | | | | | SEPT-OCT-NOV | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SWIR1 | | SWIR2 | | SWIR3 | | SWIR1 | | SWIR2 | | SWIR3 | | SWIR1 | | SWIR2 | | SWIR3 | |
| 177 | H DC NOK | 168 | H DC NOK | 494 | H DC BAD | 831 | H DC BAD | 859 | H DC BAD | 966 | H DC BAD | 3 | H DC BAD | 702 | H DC BAD | 4 | H DC BAD |
| 705 | H DC NOK | 523 | H DC NOK | 623 | H DC BAD | 3 | H DC NOK | 523 | H DC NOK | 4 | H DC NOK | 28 | H DC BAD | 922 | H DC BAD | 67 | H DC BAD |
| 831 | H DC NOK | 772 | H DC NOK | 966 | H DC BAD | 28 | H DC NOK | 702 | H DC NOK | 67 | H DC NOK | 345 | H DC BAD | 159 | H DC NOK | 115 | H DC BAD |
| 216pixels | H DC OK | 859 | H DC NOK | 52 | H DC NOK | 177 | H DC NOK | 922 | H DC NOK | 115 | H DC NOK | 886 | H DC BAD | 711 | H DC NOK | 178 | H DC BAD |
| | | 335pixels | H DC OK | 75 | H DC NOK | 345 | H DC NOK | 338pixels | H DC OK | 178 | H DC NOK | 956 | H DC BAD | 778 | H DC NOK | 204 | H DC BAD |
| | | | | 115 | H DC NOK | 705 | H DC NOK | | | 204 | H DC NOK | 78 | H DC NOK | 859 | H DC NOK | 370 | H DC BAD |
| | | | | 178 | H DC NOK | 886 | H DC NOK | | | 370 | H DC NOK | 104 | H DC NOK | 340pixels | H DC OK | 423 | H DC BAD |
| | | | | 333 | H DC NOK | 956 | H DC NOK | | | 423 | H DC NOK | 120 | H DC NOK | | | 564 | H DC BAD |
| | | | | 370 | H DC NOK | 219pixels | H DC OK | | | 494 | H DC NOK | 187 | H DC NOK | | | 568 | H DC BAD |
| | | | | 515 | H DC NOK | | | | | 564 | H DC NOK | 222 | H DC NOK | | | 769 | H DC BAD |
| | | | | 567 | H DC NOK | | | | | 568 | H DC NOK | 290 | H DC NOK | | | 966 | H DC BAD |
| | | | | 608 | H DC NOK | | | | | 608 | H DC NOK | 298 | H DC NOK | | | 193pixels | H DC NOK |
| | | | | 696 | H DC NOK | | | | | 623 | H DC NOK | 425 | H DC NOK | | | 766pixels | H DC OK |
| | | | | 737 | H DC NOK | | | | | 769 | H DC NOK | 575 | H DC NOK | | | | |
| | | | | 934 | H DC NOK | | | | | 934 | H DC NOK | 678 | H DC NOK | | | | |
| | | | | 986 | H DC NOK | | | | | 1006 | H DC NOK | 831 | H DC NOK | | | | |
| | | | | 1006 | H DC NOK | | | | | 859pixels | H DC OK | 212pixels | H DC OK | | | | |
| | | | | 834pixels | H DC OK | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

*Table 3. LEFT SWIR dark current pixel outliers (ID L1A).*

| JUL-AUG-SEPT | | | | | | AUG-SEPT-OCT | | | | | | SEPT-OCT-NOV | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SWIR1 | | SWIR2 | | SWIR3 | | SWIR1 | | SWIR2 | | SWIR3 | | SWIR1 | | SWIR2 | | SWIR3 | |
| 109 | H DC NOK | 208 | H DC BAD | 729 | H DC BAD | 69 | H DC NOK | 197 | H DC NOK | 354 | H DC BAD | 161 | H DC BAD | 831 | H DC BAD | 30 | H DC BAD |
| 305 | H DC NOK | 197 | H DC NOK | 354 | H DC NOK | 161 | H DC NOK | 208 | H DC NOK | 30 | H DC NOK | 545 | H DC BAD | 134 | H DC NOK | 99 | H DC BAD |
| 358 | H DC NOK | 648 | H DC NOK | 504 | H DC NOK | 305 | H DC NOK | 428 | H DC NOK | 99 | H DC NOK | 819 | H DC BAD | 295 | H DC NOK | 131 | H DC BAD |
| 819 | H DC NOK | 896 | H DC NOK | 163pixels | H DC OK | 337 | H DC NOK | 433 | H DC NOK | 131 | H DC NOK | 1001 | H DC BAD | 428 | H DC NOK | 354 | H DC BAD |
| 908 | H DC NOK | 286pixels | H DC OK | | | 358 | H DC NOK | 831 | H DC NOK | 448 | H DC NOK | 1021 | H DC BAD | 433 | H DC NOK | 579 | H DC BAD |
| 916 | H DC NOK | | | | | 545 | H DC NOK | 896 | H DC NOK | 513 | H DC NOK | 18 | H DC NOK | 687 | H DC NOK | 890 | H DC BAD |
| 241pixels | H DC OK | | | | | 819 | H DC NOK | 288pixels | H DC OK | 579 | H DC NOK | 69 | H DC NOK | 900 | H DC NOK | 994 | H DC BAD |
| | | | | | | 1001 | H DC NOK | | | 729 | H DC NOK | 77 | H DC NOK | 941 | H DC NOK | 152 | H DC NOK |
| | | | | | | 1021 | H DC NOK | | | 890 | H DC NOK | 133 | H DC NOK | 286pixels | H DC OK | 266 | H DC NOK |
| | | | | | | 238pixels | H DC OK | | | 952 | H DC NOK | 165 | H DC NOK | | | 272 | H DC NOK |
| | | | | | | | | | | 994 | H DC NOK | 337 | H DC NOK | | | 364 | H DC NOK |
| | | | | | | | | | | 154pixels | H DC OK | 419 | H DC NOK | | | 397 | H DC NOK |
| | | | | | | | | | | | | 547 | H DC NOK | | | 432 | H DC NOK |
| | | | | | | | | | | | | 641 | H DC NOK | | | 448 | H DC NOK |
| | | | | | | | | | | | | 792 | H DC NOK | | | 476 | H DC NOK |
| | | | | | | | | | | | | 232pixels | H DC OK | | | 504 | H DC NOK |
| | | | | | | | | | | | | | | | | 513 | H DC NOK |
| | | | | | | | | | | | | | | | | 640 | H DC NOK |
| | | | | | | | | | | | | | | | | 682 | H DC NOK |
| | | | | | | | | | | | | | | | | 697 | H DC NOK |
| | | | | | | | | | | | | | | | | 716 | H DC NOK |
| | | | | | | | | | | | | | | | | 729 | H DC NOK |
| | | | | | | | | | | | | | | | | 763 | H DC NOK |
| | | | | | | | | | | | | | | | | 804 | H DC NOK |
| | | | | | | | | | | | | | | | | 868 | H DC NOK |
| | | | | | | | | | | | | | | | | 917 | H DC NOK |
| | | | | | | | | | | | | | | | | 952 | H DC NOK |
| | | | | | | | | | | | | | | | | 957 | H DC NOK |
| | | | | | | | | | | | | | | | | 1005 | H DC NOK |
| | | | | | | | | | | | | | | | | 135pixels | H DC OK |

*Table 4. CENTER SWIR dark current pixel outliers (ID L1A)*

| JULY-AUG-SEPT | | | | | | AUG-SEPT-OCT | | | | | | SEPT-OCT-NOV | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 271 | H DC BAD | 398 | H DC BAD | 210 | H DC NOK | 271 | H DC NOK | 398 | H DC NOK | 388 | H DC BAD | 92 | H DC NOK | 14 | H DC NOK | 297 | H DC NOK |
| 575 | H DC BAD | 500 | H DC BAD | 388 | H DC NOK | 398 | H DC NOK | 500 | H DC NOK | 210 | H DC NOK | 144 | H DC NOK | 92 | H DC NOK | 300 | H DC NOK |
| 442 | H DC NOK | 778 | H DC NOK | 595 | H DC NOK | 442 | H DC NOK | 778 | H DC NOK | 595 | H DC NOK | 183 | H DC NOK | 93 | H DC NOK | 388 | H DC NOK |
| 691 | H DC NOK | 473pixels | H DC OK | 655 | H DC NOK | 521 | H DC NOK | 482pixels | H DC OK | 655 | H DC NOK | 264 | H DC NOK | 167 | H DC NOK | 492 | H DC NOK |
| 876 | H DC NOK | | | 352pixels | H DC OK | 575 | H DC NOK | | | 358pixels | H DC OK | 398 | H DC NOK | 398 | H DC NOK | 717 | H DC NOK |
| 408pixels | H DC OK | | | | | 691 | H DC NOK | | | | | 459 | H DC NOK | 438 | H DC NOK | 730 | H DC NOK |
| | | | | | | 876 | H DC NOK | | | | | 521 | H DC NOK | 580 | H DC NOK | 939 | H DC NOK |
| | | | | | | 1003 | H DC NOK | | | | | 774 | H DC NOK | 727 | H DC NOK | 352pixels | H DC OK |
| | | | | | | 422pixels | H DC OK | | | | | 873 | H DC NOK | 946 | H DC NOK | | |
| | | | | | | | | | | | | 957 | H DC NOK | 472pixels | H DC OK | | |
| | | | | | | | | | | | | 1003 | H DC NOK | | | | |
| | | | | | | | | | | | | 413pixels | H DC OK | | | | |

*Table 5. RIGHT SWIR dark current pixel outliers (ID L1A)*

## 1.4. Yaw manoeuvre: Low Frequency Equalisation

Analyses of the three yaw maneuver campaigns (on July 9,18 and 27) are still on-going.

## 1.5. Bad pixels

One new bad pixel was identified in this reporting period.

| Reporting period Mid-Sept 2018- Mid-Dec 2018 | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CAMERA | STRIP | pixel numbers (ID L1 A) | | | | | | | | | | | | | | | |
| | | NEW BAD | BAD (from previous periods) | | | | | | | | | | | | | | |
| left | swir1 | 39 | 3 | 28 | 104 | 298 | 345 | 352 | 644 | 956 | | | | | | | |
| left | swir2 | | 711 | 863 | | | | | | | | | | | | | |
| left | swir3 | | 90 | 172 | 250 | 370 | 419 | 438 | 568 | 759 | 761 | | | | | | |
| center | swir1 | | 819 | 1021 | | | | | | | | | | | | | |
| center | swir2 | | 57 | 295 | 769 | 831 | 900 | | | | | | | | | | |
| center | swir3 | | 29 | 30 | 99 | 131 | 448 | 476 | 579 | 640 | 763 | 804 | 889 | 890 | 917 | 938 | 994 |
| right | swir1 | | | | | | | | | | | | | | | | |
| right | swir2 | | 14 | 438 | 470 | | | | | | | | | | | | |
| right | swir3 | | | | | | | | | | | | | | | | |

*Table 6: Overview Bad pixels*

## 1.6. Radiometric ICP file

The updates to the radiometric ICP file used within the user segment for the processing of the nominal PROBA-V data by PF are listed in the Table 9 for collection 1.

| | |
|---|---|
| PROBAV_X_R_000_YEARMN01_**101**.xml* | Update dark currents<br>Update of SWIR absolute following linear degradation model** |
| PROBAV_X_R_000_20161201_01.xml | Update dark currents<br>Update of SWIR absolute following linear degradation model** |
| PROBAV_X_R_000_20161201_01.xml | Update dark currents<br>Update of SWIR absolute following linear degradation model** |
| PROBAV_X_R_000_20161201_01.xml | Update dark currents<br>Update of SWIR absolute following linear degradation model** |
| PROBAV_X_R_000_20161201_01.xml | Update dark currents<br>Update of SWIR absolute following linear degradation model** |
| PROBAV_X_R_000_20170101_01.xml | Update dark currents<br>Update of SWIR absolute following linear degradation model** |
| PROBAV_X_R_000_20170120_01.xml | SWIR status map updated : 1 bad pixel added |
| PROBAV_X_R_000_20170201_01.xml | Update dark currents<br>Update of SWIR absolute following linear degradation model** |
| PROBAV_X_R_000_20170220_01.xml | SWIR status map updated : 1 bad pixel added |

| | |
|---|---|
| PROBAV_X_R_000_20170301_01.xml | Update dark currents<br>Update of SWIR absolute following linear degradation model** |
| PROBAV_X_R_000_20170401_01.xml | Update dark currents<br>Update of SWIR absolute following linear degradation model**<br>SWIR status map updated : 1 bad pixel added |
| PROBAV_X_R_000_2017051_01.xml | Update dark currents<br>Update of SWIR absolute following linear degradation model**<br>Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model*** |
| PROBAV_X_R_000_20170601_01.xml | Update dark currents<br>Update of SWIR absolute following linear degradation model**<br>Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model*** |
| PROBAV_X_R_000_20170701_01.xml | Update dark currents<br>Update of SWIR absolute following linear degradation model**<br>Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model***<br>SWIR status map updated : 1 bad pixel added |
| PROBAV_X_R_000_20170801_01.xml | Update dark currents<br>Update of SWIR absolute following linear degradation model**<br>Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model***<br>SWIR status map updated : 2 bad pixel added |
| PROBAV_X_R_000_20170901_01.xml | Update dark currents<br>Update of SWIR absolute following linear degradation model***, new coef applied for RIGHT SWIR strips*****<br>Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** ****<br>SWIR status map updated : 2 bad pixel added |

| | |
|---|---|
| PROBAV_X_R_000_20171001_01.xml | Update dark currents<br>Update of SWIR absolute following linear degradation model***, new coef applied for RIGHT SWIR strips*****<br>Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** |
| PROBAV_X_R_000_20171101_01.xml | Update dark currents<br>Update of SWIR absolute following linear degradation model***, new coef applied for RIGHT SWIR strips*****<br>Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** |
| PROBAV_X_R_000_20171201_01.xml | Update dark currents<br>Update of SWIR absolute following linear degradation model***, new coef applied for RIGHT SWIR strips*****<br>Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** |
| PROBAV_X_R_000_20180101_01.xml | Update dark currents<br>Update of LEFT and CENTER SWIR absolute following linear degradation model***; **No update of RIGHT SWIR absolute cal**.. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** |
| PROBAV_X_R_000_20180201_01.xml | Update dark currents<br>Update of LEFT and CENTER SWIR absolute following linear degradation model***; **No update of RIGHT SWIR absolute cal**.. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** |
| PROBAV_X_R_000_20180301_01.xml | Update dark currents<br>Update of LEFT and CENTER SWIR absolute following linear degradation model***; **No update of RIGHT SWIR absolute cal**.. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients |

| | |
|---|---|
| | following linear degradation model **with new coef** **** |
| PROBAV_X_R_000_20180401_01.xml | Update dark currents<br>Update of LEFT and CENTER SWIR absolute following linear degradation model***; **No update of RIGHT SWIR absolute cal**.. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** |
| PROBAV_X_R_000_20180501_01.xml | Update dark currents<br>Update of LEFT and CENTER SWIR absolute following linear degradation model***; **No update of RIGHT SWIR absolute cal**.. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** |
| PROBAV_X_R_000_20180601_01.xml | Update dark currents<br>Update of LEFT and CENTER SWIR absolute following linear degradation model***; **No update of RIGHT SWIR absolute cal**.. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** |
| PROBAV_X_R_000_20180701_01.xml | Update dark currents<br>Update of LEFT and CENTER SWIR absolute following linear degradation model***; **No update of RIGHT SWIR absolute cal**.. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** |
| PROBAV_X_R_000_20180801_01.xml | Update dark currents<br>Update of LEFT and CENTER SWIR absolute following linear degradation model***; **No update of RIGHT SWIR absolute cal**.. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** |

| | |
|---|---|
| PROBAV_X_R_000_20180821_01.xml | SWIR status map updated : 1 bad pixel added for SWIR2 center camera + correction for assignment of bad pixel status to wrong pixel ID |
| PROBAV_X_R_000_20180901_01.xml | Update dark currents<br>Update of LEFT and CENTER SWIR absolute following linear degradation model***; **No update of RIGHT SWIR absolute cal**.. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** |
| PROBAV_X_R_000_20181001_01.xml | Update dark currents.<br>Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** |
| PROBAV_X_R_000_20181101_01.xml | Update dark currents.<br>Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** |
| PROBAV_X_R_000_20181201_01.xml | Update dark currents.<br>Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** |

*Table 7: Radiometric ICP-file updates Collection 1*

# 2. Geometric Image Quality

## 2.1. Summary

The quarterly Average Location Error (ALE) over the period 16/9/2018 – 15/12/2018 was 71 m (1σ = 83 m) for all spectral bands (combined cameras). Compared to the previous reporting period, the ALE has decreased (improved) by 1%. The total number of chips per day and per spectral band used for the geometric accuracy analysis decreased by 17% on average compared to the previous reporting period. Between 19 and 21 September, a geolocation issue with exceptionally high values (> 500 m) occurred of which at first instance no cause was found. We have escalated this issue to QinetiQ and we will report on their findings in the next QIR.

The daily average location error compliance (ALE < 300m) was 99.21%, which is 0.02% lower than in previous quarter. The inter-band geometric accuracy was 34 – 55 m (σ = 8 – 21 m), which is 0.10 – 0.17 of a pixel (333 m), a result that is slightly higher than in previous quarter.

The multi-temporal geometric accuracy was 52.82% (30.34% lower compared to previous quarter) for the VNIR and 74.00% (21.1% lower compared to previous quarter) for the combined VNIR/SWIR. The multi-temporal accuracies over the last full year are 74.66% and 89.54% for VNIR and VNIR/SWIR, respectively. The reason for this sharp decline in multi-temporal accuracy is unknown but might be connected to the earlier mentioned issue of 19 – 21 September. We will closely monitor the accuracy's evolution throughout next quarter and perform additional actions when necessary.

The geometric ICP file generated on 8/9/2016, valid from 1/9/2016 has remained valid throughout the reporting period.

## 2.2. Assessment of the geometric accuracy on L1C data

The absolute location error (ALE) and accompanying standard deviation of the Level1C data is presented in the tables below for each camera, spectral band/strip and reporting month.

| CAMERA 1 Mean and standard deviation ALE [m] | | | |
|---|---|---|---|
| **Strip\Period** | **16/9/2018 - 15/10/2018** | **16/10/2018 - 15/11/2018** | **16/11/2018 - 15/12/2018** |
| **BLUE** | 60.01, σ = 48.67 | 58.36, σ = 35.01 | 57.08, σ = 33.22 |
| **RED** | 63.20, σ = 53.58 | 60.00, σ = 36.76 | 58.34, σ = 34.99 |
| **NIR** | 63.61, σ = 55.47 | 61.24, σ = 37.15 | 61.29, σ = 36.85 |
| **SWIR1** | 92.24, σ = 76.10 | 87.73, σ = 53.85 | 91.68, σ = 55.38 |
| **SWIR2** | 63.18, σ = 49.29 | 61.91, σ = 34.31 | 61.59, σ = 34.21 |
| **SWIR3** | 55.46, σ = 37.47 | 57.79, σ = 32.59 | 57.32, σ = 32.67 |

*Table 8: Mean absolute location error and standard deviation (σ) for camera 1.*

| CAMERA 2 Mean and standard deviation ALE [m] | | | |
|---|---|---|---|
| **Strip\Period** | **16/9/2018 - 15/10/2018** | **16/10/2018 - 15/11/2018** | **16/11/2018 - 15/12/2018** |
| **BLUE** | 67.83, σ = 44.42 | 68.58, σ = 40.03 | 64.84, σ = 36.22 |
| **RED** | 69.37, σ = 44.51 | 69.80, σ = 40.43 | 65.98, σ = 36.56 |
| **NIR** | 65.85, σ = 43.46 | 70.04, σ = 40.95 | 66.85, σ = 37.35 |
| **SWIR1** | 68.18, σ = 42.18 | 72.48, σ = 41.40 | 70.19, σ = 37.74 |
| **SWIR2** | 69.67, σ = 44.93 | 73.36, σ = 42.35 | 66.90, σ = 38.88 |
| **SWIR3** | 69.51, σ = 45.96 | 73.57, σ = 43.42 | 65.84, σ = 39.95 |

*Table 9: Mean absolute location error and standard deviation (σ) for camera 2.*

| CAMERA 3 Mean and standard deviation ALE [m] | | | |
|---|---|---|---|
| **Strip\Period** | **16/9/2018 - 15/10/2018** | **16/10/2018 - 15/11/2018** | **16/11/2018 - 15/12/2018** |
| **BLUE** | 73.90, σ = 61.20 | 69.83, σ = 42.18 | 65.44, σ = 37.63 |
| **RED** | 78.94, σ = 64.94 | 74.76, σ = 47.40 | 72.28, σ = 43.39 |
| **NIR** | 73.39, σ = 64.33 | 68.14, σ = 44.34 | 67.20, σ = 43.05 |
| **SWIR1** | 61.70, σ = 47.23 | 64.32, σ = 39.34 | 67.07, σ = 40.52 |
| **SWIR2** | 71.94, σ = 58.53 | 71.49, σ = 44.25 | 71.68, σ = 45.08 |
| **SWIR3** | 95.35, σ = 79.47 | 93.14, σ = 60.27 | 94.77, σ = 60.94 |

*Table 10: Mean absolute location error and standard deviation (σ) for camera 3.*

In the reporting period the average location error of the Level 1C data was 69.4 m, which is 10.2 m (17.2%) higher than in the previous quarter.

## 2.3. Assessment of the geometric accuracy on L2 data

### 2.3.1. Absolute geometric accuracy

The daily summary of the L2 data absolute location error for all spectral bands is presented in the tables and figures below for the three reporting months:

- from 16/9/2018 – 15/10/2018
- from 16/10/2018 – 15/11/2018
- from 16/11/2018 – 15/12/2018

The tables list:

- The day of the measurement in format dd-mm-yy
- The daily achieved compliance (%B) for the BLUE band (% of GCP where ALE <=300m)
- The daily achieved compliance (%R) for the RED band (% of GCP where ALE <=300m)
- The daily achieved compliance (%N) for the NIR band (% of GCP where ALE <=300m)
- The daily achieved compliance (%S) for the SWIR band (% of GCP where ALE <=450m)

- The number of GCP per day (NB-B) used to derive the absolute location error ALE for the BLUE band
- The daily average ALE (in m) for the BLUE band (MU-B)
- The daily ALE standard deviation (in m) for the BLUE band (STD-B)

- The number of GCP per day (NB-R) used to derive the absolute location error ALE for the RED band
- The daily average ALE (in m) for the RED band (MU-R)
- The daily ALE standard deviation (in m) for the RED band (STD-R)

- The number of GCP per day (NB-N) used to derive the absolute location error ALE for the NIR band
- The daily average ALE (in m) for the NIR band (MU-N)
- The daily ALE standard deviation (in m) for the NIR band (STD-N)

- The number of GCP per day (NB-S) used to derive the absolute location error ALE for the SWIR band
- The daily average ALE (in m) for the SWIR band (MU-S)
- The daily ALE standard deviation (in m) for the SWIR band (STD-S)

| Day | %B | %R | %N | %S | NB-B | MU-B | STD-B | NB-R | MU-R | STD-R | NB-N | MU-N | STD-N | NB-S | MU-S | STD-S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16/09/2018 | 99.03 | 99.32 | 99.38 | 99.74 | 43356 | 64.44 | 88.76 | 49223 | 59.41 | 81.43 | 51008 | 56.86 | 74.25 | 54753 | 57.01 | 73.79 |
| 17/09/2018 | 99.00 | 99.38 | 99.45 | 99.77 | 42747 | 64.53 | 88.95 | 48429 | 58.91 | 72.36 | 49145 | 56.72 | 71.41 | 52826 | 56.83 | 68.20 |
| 18/09/2018 | 99.06 | 99.34 | 99.51 | 99.79 | 45053 | 61.68 | 85.14 | 51687 | 55.96 | 69.80 | 52463 | 52.57 | 63.45 | 56043 | 54.47 | 70.33 |
| 19/09/2018 | Under investigation | | | | | | | | | | | | | | | |
| 20/09/2018 | Under investigation | | | | | | | | | | | | | | | |
| 21/09/2018 | Under investigation | | | | | | | | | | | | | | | |
| 22/09/2018 | 98.94 | 99.28 | 99.32 | 99.77 | 37630 | 74.02 | 91.80 | 45028 | 68.36 | 79.80 | 44688 | 64.51 | 75.19 | 47895 | 65.32 | 71.04 |
| 23/09/2018 | 98.96 | 99.41 | 99.49 | 99.81 | 39290 | 71.32 | 93.27 | 47550 | 63.74 | 69.16 | 48821 | 60.47 | 67.36 | 53190 | 61.28 | 63.15 |
| 24/09/2018 | 99.05 | 99.38 | 99.54 | 99.79 | 37064 | 67.80 | 91.39 | 43235 | 61.57 | 76.28 | 45392 | 58.43 | 74.86 | 48411 | 59.92 | 73.20 |
| 25/09/2018 | 98.97 | 99.41 | 99.47 | 99.74 | 37270 | 71.86 | 98.34 | 42247 | 65.20 | 77.55 | 42796 | 61.52 | 65.24 | 47403 | 62.40 | 78.76 |
| 26/09/2018 | 98.69 | 99.19 | 99.20 | 99.68 | 38838 | 73.92 | 99.88 | 43065 | 68.88 | 81.47 | 43198 | 66.01 | 76.71 | 47256 | 66.00 | 81.55 |
| 27/09/2018 | 99.11 | 99.25 | 99.28 | 99.73 | 40368 | 71.27 | 84.28 | 45506 | 68.00 | 76.11 | 46362 | 65.26 | 76.40 | 49558 | 64.69 | 80.94 |
| 28/09/2018 | 98.71 | 99.12 | 99.20 | 99.76 | 35998 | 86.91 | 92.34 | 41524 | 81.79 | 81.12 | 41589 | 77.60 | 77.87 | 45778 | 73.75 | 76.60 |
| 29/09/2018 | 98.24 | 98.47 | 98.54 | 99.70 | 32256 | 97.36 | 98.98 | 38064 | 94.14 | 92.60 | 38422 | 89.53 | 84.23 | 43334 | 85.09 | 81.31 |
| 30/09/2018 | 97.79 | 97.97 | 97.87 | 99.57 | 27026 | 107.91 | 113.42 | 29508 | 105.61 | 94.14 | 28955 | 100.21 | 90.51 | 32770 | 93.81 | 95.46 |
| 01/10/2018 | 97.97 | 98.11 | 98.05 | 99.70 | 32983 | 96.39 | 99.46 | 37877 | 93.22 | 89.23 | 37860 | 88.65 | 88.60 | 41394 | 86.28 | 85.39 |
| 02/10/2018 | 98.78 | 99.04 | 98.93 | 99.76 | 36867 | 81.39 | 87.71 | 41589 | 75.96 | 77.63 | 41625 | 71.46 | 76.12 | 44085 | 72.38 | 78.59 |
| 03/10/2018 | 98.97 | 99.30 | 99.21 | 99.76 | 36466 | 71.41 | 90.69 | 41552 | 66.41 | 79.96 | 38489 | 65.95 | 83.72 | 43797 | 65.75 | 78.99 |
| 04/10/2018 | 98.81 | 99.06 | 99.00 | 99.68 | 28731 | 79.28 | 93.55 | 31543 | 75.40 | 91.74 | 30515 | 73.04 | 89.62 | 35405 | 71.22 | 82.95 |
| 05/10/2018 | 98.47 | 98.97 | 98.83 | 99.68 | 38689 | 83.12 | 99.16 | 37830 | 80.24 | 84.65 | 37249 | 75.65 | 81.81 | 41092 | 72.93 | 80.32 |
| 06/10/2018 | 98.73 | 98.99 | 99.19 | 99.76 | 35568 | 76.62 | 90.61 | 39932 | 71.40 | 78.60 | 39423 | 68.10 | 78.18 | 40900 | 66.66 | 73.60 |
| 07/10/2018 | 99.04 | 99.40 | 99.43 | 99.74 | 37314 | 74.67 | 85.74 | 41660 | 66.90 | 67.92 | 40084 | 63.83 | 74.71 | 41796 | 64.55 | 72.65 |
| 08/10/2018 | 98.57 | 99.04 | 99.09 | 99.69 | 33402 | 79.45 | 98.31 | 38901 | 72.56 | 80.91 | 36854 | 68.80 | 86.40 | 34865 | 67.39 | 78.71 |
| 09/10/2018 | 98.66 | 99.25 | 99.24 | 99.70 | 33704 | 77.01 | 100.78 | 38237 | 68.99 | 82.71 | 36582 | 66.74 | 78.33 | 40608 | 65.41 | 78.03 |
| 10/10/2018 | 98.91 | 99.49 | 99.45 | 99.76 | 21732 | 66.70 | 87.60 | 22799 | 59.43 | 68.22 | 21798 | 58.54 | 71.14 | 21645 | 58.90 | 71.16 |
| 11/10/2018 | 99.08 | 99.50 | 99.52 | 99.76 | 38766 | 60.64 | 81.05 | 44130 | 54.47 | 67.45 | 41309 | 53.72 | 65.91 | 43979 | 56.77 | 70.49 |
| 12/10/2018 | 99.12 | 99.45 | 99.43 | 99.73 | 35855 | 60.97 | 82.07 | 41146 | 55.76 | 77.37 | 40949 | 55.80 | 75.03 | 44834 | 57.27 | 74.16 |
| 13/10/2018 | 98.99 | 99.25 | 99.30 | 99.69 | 35295 | 63.80 | 92.57 | 38760 | 58.87 | 82.73 | 36780 | 59.20 | 78.09 | 39609 | 59.19 | 80.58 |
| 14/10/2018 | 98.91 | 99.35 | 99.33 | 99.75 | 30865 | 67.52 | 91.38 | 31865 | 62.19 | 74.97 | 27867 | 63.40 | 73.24 | 28342 | 64.67 | 79.46 |
| 15/10/2018 | 98.95 | 99.88 | 99.49 | 99.77 | 2846 | 65.98 | 69.10 | 2466 | 57.54 | 52.08 | 2353 | 65.01 | 66.67 | 3081 | 64.52 | 56.31 |
| **Averages** | **98.8** | **99.17** | **99.18** | **99.73** | **34665** | **74.74** | **91.72** | **39087** | **69.29** | **78.07** | **38613** | **66.95** | **76.48** | **41653** | **66.46** | **76.14** |

*Table 11: Daily achieved compliance and the daily average location error (in m) for all spectral bands in the period 16/9/2018 to 15/10/2018.*

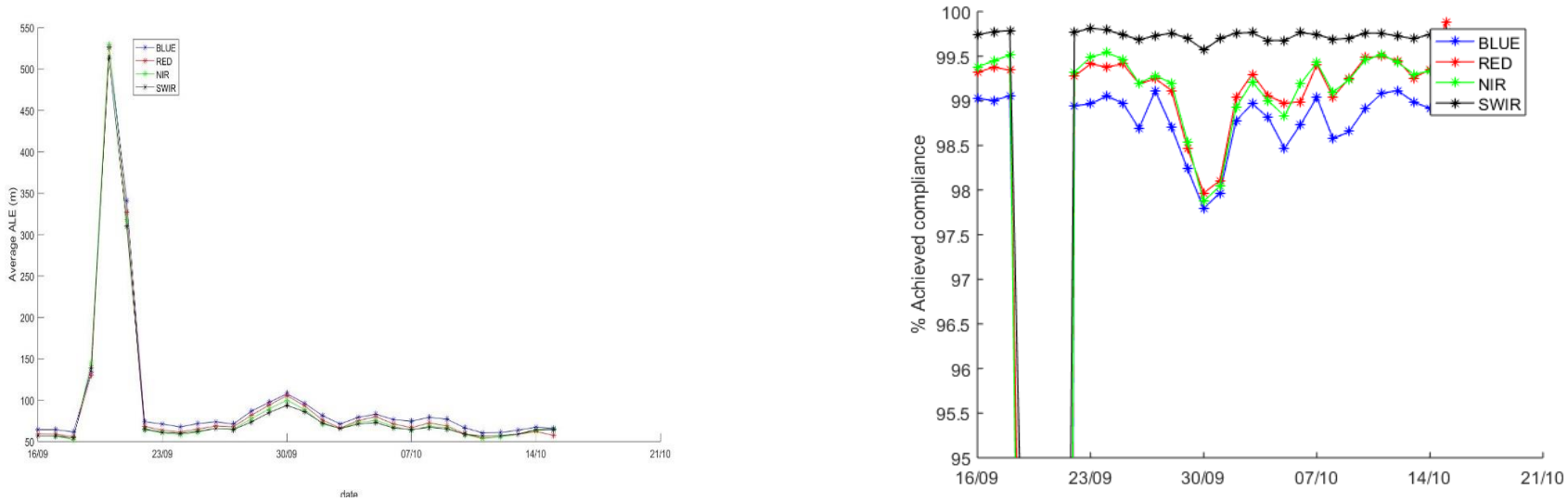



*Figure 18: Daily average location error in the period from 16/9/2018 – 15/10/2018 (left) and the average daily compliance of the spectral bands (right).*

Between 19 and 21 September, a geolocation issue with exceptionally high values (> 500 m) occurred for which at first instance no cause was found. Therefore, we have escalated this issue to QinetiQ for more detailed analysis and we will report on their findings in the next QIR. The ALE values for these days were discarded from Table 11 and the calculation of the statistics.

| Day | %B | %R | %N | %S | NB-B | MU-B | STD-B | NB-R | MU-R | STD-R | NB-N | MU-N | STD-N | NB-S | MU-S | STD-S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16/10/2018 | 98.49 | 99.24 | 99.25 | 99.71 | 36005 | 76.29 | 95.74 | 40702 | 71.96 | 81.76 | 39490 | 74.81 | 80.27 | 43083 | 75.80 | 80.19 |
| 17/10/2018 | 98.64 | 99.27 | 99.28 | 99.71 | 35584 | 72.68 | 96.72 | 39588 | 67.45 | 87.44 | 38397 | 70.28 | 81.39 | 41696 | 69.88 | 83.51 |
| 18/10/2018 | 98.74 | 99.27 | 99.30 | 99.67 | 34243 | 68.00 | 95.78 | 37003 | 61.07 | 76.64 | 36891 | 61.89 | 72.90 | 39157 | 63.44 | 74.65 |
| 19/10/2018 | 98.96 | 99.33 | 99.40 | 99.74 | 35431 | 63.48 | 93.47 | 39193 | 57.37 | 74.70 | 38850 | 55.93 | 72.76 | 39456 | 58.55 | 70.39 |
| 20/10/2018 | 99.24 | 99.55 | 99.53 | 99.80 | 34217 | 63.78 | 83.26 | 38847 | 57.55 | 70.00 | 37234 | 55.35 | 67.07 | 38869 | 57.00 | 68.67 |
| 21/10/2018 | 99.02 | 99.33 | 99.44 | 99.81 | 30631 | 70.59 | 91.66 | 35973 | 63.95 | 77.83 | 36772 | 61.22 | 75.25 | 37879 | 61.61 | 66.87 |
| 22/10/2018 | 98.94 | 99.33 | 99.36 | 99.68 | 28374 | 68.20 | 99.33 | 33117 | 61.17 | 82.61 | 34042 | 59.26 | 78.25 | 35305 | 60.92 | 75.44 |
| 23/10/2018 | 98.84 | 99.32 | 99.28 | 99.64 | 30100 | 67.66 | 99.06 | 33941 | 59.48 | 71.90 | 33503 | 58.30 | 74.16 | 33706 | 61.03 | 79.59 |
| 24/10/2018 | 99.06 | 99.34 | 99.43 | 99.68 | 31070 | 62.89 | 92.35 | 36412 | 57.41 | 77.64 | 36847 | 56.31 | 69.00 | 37435 | 58.75 | 83.12 |
| 25/10/2018 | 99.04 | 99.46 | 99.42 | 99.70 | 29705 | 63.85 | 90.87 | 35293 | 56.98 | 70.17 | 33071 | 58.15 | 74.13 | 35117 | 60.49 | 75.80 |
| 26/10/2018 | 98.75 | 99.33 | 99.25 | 99.74 | 29868 | 68.22 | 100.87 | 35476 | 60.62 | 84.59 | 33288 | 61.10 | 78.39 | 35957 | 60.70 | 74.72 |
| 27/10/2018 | 98.84 | 99.40 | 99.31 | 99.69 | 31868 | 66.86 | 97.98 | 36383 | 57.63 | 81.19 | 34021 | 58.21 | 80.58 | 35188 | 60.98 | 82.61 |
| 28/10/2018 | 98.94 | 99.38 | 99.38 | 99.74 | 29932 | 65.26 | 84.58 | 33654 | 58.05 | 75.77 | 32929 | 57.27 | 74.56 | 33181 | 60.71 | 72.92 |
| 29/10/2018 | 99.05 | 99.43 | 99.37 | 99.73 | 32122 | 66.67 | 91.26 | 36064 | 59.04 | 73.46 | 33587 | 58.29 | 71.82 | 34275 | 61.84 | 78.02 |
| 30/10/2018 | 98.77 | 99.34 | 99.21 | 99.67 | 27454 | 72.66 | 91.14 | 31239 | 65.31 | 82.08 | 31018 | 64.36 | 87.27 | 30973 | 67.87 | 85.64 |
| 31/10/2018 | 98.88 | 99.31 | 99.30 | 99.66 | 27823 | 74.38 | 94.68 | 31130 | 67.65 | 83.90 | 30650 | 66.02 | 88.17 | 30970 | 69.68 | 82.44 |
| 01/11/2018 | 98.47 | 99.10 | 99.06 | 99.58 | 24892 | 80.55 | 107.02 | 26794 | 74.05 | 84.31 | 26049 | 70.32 | 83.37 | 25005 | 73.69 | 86.27 |
| 02/11/2018 | 98.77 | 99.11 | 99.20 | 99.69 | 34489 | 78.13 | 86.32 | 37163 | 73.12 | 78.38 | 35944 | 68.81 | 71.14 | 36307 | 70.62 | 86.33 |
| 03/11/2018 | 99.10 | 99.45 | 99.51 | 99.70 | 31632 | 74.95 | 83.81 | 34478 | 69.27 | 75.23 | 33942 | 65.90 | 68.14 | 33674 | 68.74 | 76.77 |
| 04/11/2018 | 98.62 | 99.19 | 99.22 | 99.72 | 29388 | 75.43 | 95.05 | 33688 | 69.22 | 85.04 | 33049 | 65.80 | 77.30 | 33549 | 67.69 | 77.01 |
| 05/11/2018 | 98.76 | 99.18 | 99.04 | 99.61 | 28834 | 74.46 | 101.79 | 31879 | 69.86 | 88.03 | 30406 | 69.48 | 87.51 | 29938 | 70.22 | 93.20 |
| 06/11/2018 | 98.62 | 99.07 | 99.02 | 99.69 | 30326 | 81.16 | 88.88 | 33585 | 76.81 | 85.99 | 32609 | 74.92 | 85.30 | 33277 | 76.65 | 84.79 |
| 07/11/2018 | 98.80 | 99.08 | 99.15 | 99.72 | 30192 | 83.65 | 87.31 | 33995 | 79.08 | 72.01 | 32461 | 75.86 | 72.59 | 33473 | 77.76 | 81.07 |
| 08/11/2018 | 98.73 | 99.19 | 99.17 | 99.70 | 30118 | 86.33 | 98.53 | 33994 | 81.63 | 89.24 | 33502 | 77.79 | 90.35 | 34160 | 78.80 | 81.52 |
| 09/11/2018 | 98.14 | 98.74 | 98.72 | 99.62 | 26449 | 92.59 | 107.73 | 28725 | 86.62 | 88.48 | 27912 | 81.57 | 81.27 | 28318 | 83.76 | 93.88 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10/11/2018 | 97.28 | 97.75 | 97.75 | 99.54 | 26252 | 120.34 | 104.04 | 28091 | 115.39 | 95.61 | 27899 | 108.55 | 86.71 | 27172 | 107.83 | 92.92 |
| 11/11/2018 | 97.67 | 98.16 | 98.30 | 99.69 | 30752 | 115.58 | 100.00 | 34195 | 110.62 | 83.59 | 33808 | 104.78 | 82.07 | 32963 | 104.62 | 83.13 |
| 12/11/2018 | 98.21 | 99.02 | 99.16 | 99.73 | 29263 | 100.33 | 89.87 | 33308 | 92.23 | 74.05 | 31259 | 87.38 | 69.53 | 33207 | 90.50 | 78.48 |
| 13/11/2018 | 98.27 | 99.28 | 99.11 | 99.64 | 12976 | 84.92 | 114.04 | 15415 | 71.95 | 87.46 | 14333 | 70.44 | 94.34 | 15834 | 75.00 | 78.76 |
| 14/11/2018 | 98.53 | 99.30 | 99.34 | 99.75 | 12568 | 81.47 | 101.19 | 10447 | 70.84 | 68.41 | 10379 | 66.93 | 57.78 | 10389 | 76.20 | 71.06 |
| 15/11/2018 | 98.35 | 99.13 | 99.27 | 99.74 | 13896 | 90.37 | 94.64 | 12200 | 79.72 | 74.47 | 10730 | 76.57 | 65.22 | 10088 | 83.69 | 69.94 |
| **Averages** | **98.68** | **99.17** | **99.17** | **99.69** | **29999** | **77.24** | **95.28** | **33769** | **70.78** | **80.66** | **32888** | **68.91** | **78.47** | **33762** | **70.87** | **80.30** |

*Table 12: Daily achieved compliance and the daily average location error (in m) for all spectral bands in the period 16/10/2018 – 15/11/2018.*

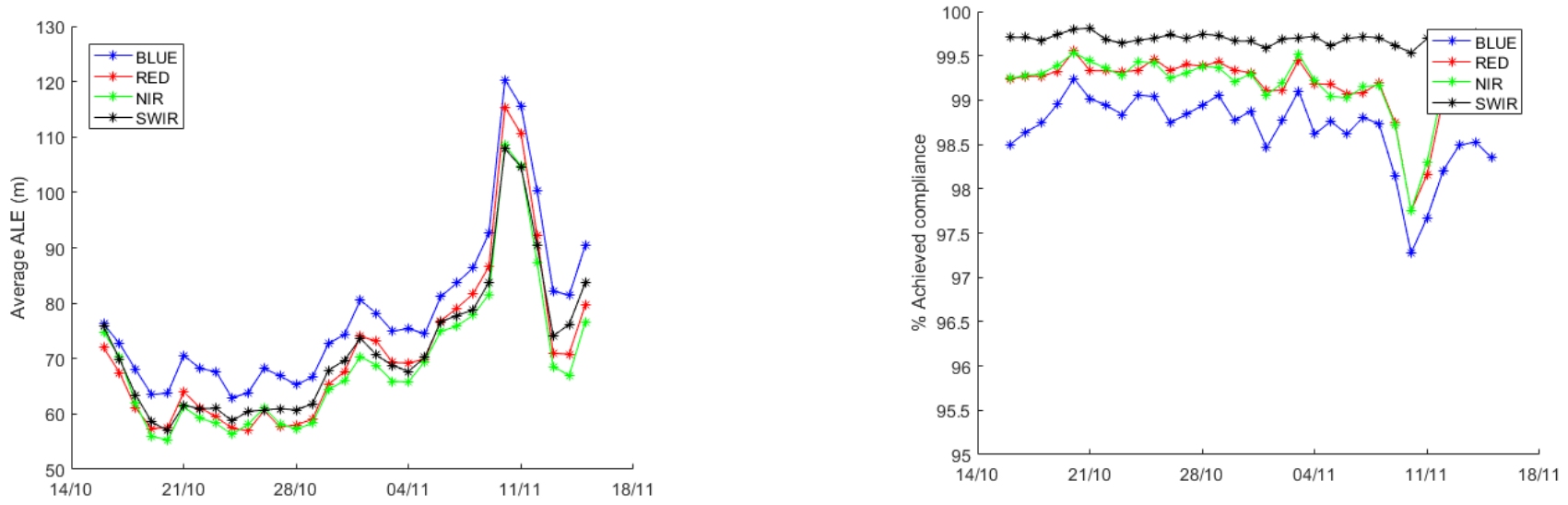



*Figure 19: Daily average location error in the period from 16/10/2018 – 15/11/2018 (left) and the average daily compliance of all spectral bands (right).*

| Day | %B | %R | %N | %S | NB-B | MU-B | STD-B | NB-R | MU-R | STD-R | NB-N | MU-N | STD-N | NB-S | MU-S | STD-S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16/11/2018 | 98.78 | 99.29 | 99.29 | 99.80 | 32457 | 87.39 | 85.60 | 37531 | 80.18 | 71.23 | 34404 | 75.72 | 69.36 | 29549 | 82.50 | 74.72 |
| 17/11/2018 | 98.67 | 99.36 | 99.34 | 99.72 | 25101 | 86.32 | 93.05 | 28309 | 76.20 | 76.33 | 26818 | 72.80 | 76.62 | 26610 | 79.33 | 80.69 |
| 18/11/2018 | 98.75 | 99.29 | 99.30 | 99.62 | 27036 | 75.36 | 100.74 | 28317 | 66.42 | 80.39 | 27787 | 64.30 | 80.79 | 26375 | 71.80 | 85.24 |
| 19/11/2018 | 98.85 | 99.31 | 99.30 | 99.63 | 27413 | 68.42 | 97.96 | 30031 | 59.45 | 81.37 | 27272 | 58.94 | 73.48 | 26127 | 65.16 | 81.13 |
| 20/11/2018 | 98.88 | 99.31 | 99.33 | 99.80 | 28758 | 70.06 | 87.51 | 32918 | 62.09 | 68.85 | 30393 | 61.43 | 67.86 | 28996 | 66.02 | 77.25 |
| 21/11/2018 | 98.84 | 99.49 | 99.47 | 99.71 | 26741 | 74.26 | 91.92 | 30115 | 66.75 | 70.88 | 29256 | 65.00 | 74.77 | 29343 | 71.35 | 86.76 |
| 22/11/2018 | 98.62 | 99.30 | 99.34 | 99.66 | 26892 | 76.55 | 99.91 | 29998 | 68.87 | 80.63 | 29909 | 66.14 | 84.35 | 28841 | 71.97 | 82.61 |
| 23/11/2018 | 98.62 | 99.06 | 99.24 | 99.73 | 25316 | 81.68 | 101.58 | 27561 | 74.41 | 75.56 | 27350 | 71.77 | 79.36 | 26844 | 76.61 | 75.63 |
| 24/11/2018 | 98.56 | 99.05 | 99.20 | 99.65 | 24549 | 86.14 | 99.53 | 28312 | 77.95 | 83.34 | 27269 | 73.73 | 74.60 | 27070 | 81.48 | 88.03 |
| 25/11/2018 | 98.87 | 99.45 | 99.47 | 99.72 | 26844 | 80.53 | 98.24 | 30722 | 70.37 | 66.28 | 29288 | 66.99 | 72.61 | 28435 | 74.48 | 77.55 |
| 26/11/2018 | 98.86 | 99.42 | 99.42 | 99.67 | 16473 | 84.82 | 102.44 | 18534 | 74.98 | 69.33 | 18003 | 71.35 | 74.22 | 18357 | 79.32 | 86.15 |
| 27/11/2018 | 98.42 | 99.00 | 99.12 | 99.64 | 22504 | 88.63 | 102.92 | 25018 | 81.12 | 80.84 | 25359 | 77.41 | 83.90 | 24402 | 83.95 | 91.61 |
| 28/11/2018 | 98.62 | 99.29 | 99.20 | 99.67 | 25111 | 80.11 | 98.54 | 27137 | 71.51 | 73.33 | 27064 | 70.22 | 79.04 | 25854 | 75.16 | 81.08 |
| 29/11/2018 | 98.43 | 99.08 | 99.01 | 99.65 | 28925 | 77.11 | 94.93 | 31811 | 71.07 | 80.59 | 31173 | 67.47 | 75.56 | 29562 | 71.88 | 87.51 |
| 30/11/2018 | 98.98 | 99.53 | 99.48 | 99.77 | 26376 | 69.39 | 90.12 | 29795 | 61.70 | 63.81 | 29443 | 59.95 | 69.89 | 28421 | 63.83 | 74.07 |
| 01/12/2018 | 98.74 | 99.37 | 99.41 | 99.76 | 23099 | 68.21 | 101.57 | 27618 | 60.54 | 78.24 | 27427 | 58.77 | 74.19 | 27406 | 61.03 | 72.82 |
| 02/12/2018 | 98.80 | 99.41 | 99.37 | 99.72 | 26946 | 66.25 | 101.41 | 30610 | 59.78 | 68.61 | 30398 | 60.59 | 74.74 | 29655 | 61.03 | 77.77 |
| 03/12/2018 | 98.72 | 99.17 | 99.24 | 99.68 | 26412 | 70.87 | 92.83 | 28839 | 66.14 | 75.37 | 28531 | 67.22 | 76.51 | 26040 | 67.83 | 81.30 |
| 04/12/2018 | 99.32 | 99.54 | 99.57 | 99.84 | 17986 | 62.6 | 76.15 | 19707 | 56.33 | 72.2 | 18160 | 54.95 | 62.54 | 16579 | 59.48 | 62.42 |
| 05/12/2018 | 98.82 | 99.53 | 99.48 | 99.73 | 22748 | 69.89 | 89.34 | 25808 | 61.69 | 72.37 | 27121 | 61.44 | 77.15 | 25399 | 64.9 | 79.57 |
| 06/12/2018 | 98.15 | 98.84 | 99.13 | 99.65 | 13258 | 78.28 | 105.11 | 14847 | 71.01 | 90.34 | 15024 | 67.62 | 82.45 | 12895 | 68.36 | 80.58 |
| 07/12/2018 | 98.45 | 99.06 | 99.21 | 99.79 | 17574 | 78.21 | 96.77 | 18862 | 69.51 | 83.03 | 17946 | 64.92 | 67.18 | 15010 | 68.35 | 74.11 |
| 08/12/2018 | 98.3 | 99.22 | 99.27 | 99.69 | 15556 | 83.1 | 88.32 | 16749 | 73.5 | 80.89 | 16794 | 69.23 | 74.5 | 14973 | 75.88 | 81.11 |
| 09/12/2018 | 98.61 | 99.32 | 99.41 | 99.71 | 27605 | 87.19 | 97.39 | 28201 | 75.53 | 75.57 | 28343 | 69.91 | 68.28 | 26392 | 79.28 | 76.87 |
| 10/12/2018 | 98.64 | 99.19 | 99.2 | 99.67 | 19236 | 79.96 | 90.36 | 20448 | 73.31 | 87.56 | 19765 | 69.38 | 87.18 | 16154 | 79.86 | 87.98 |
| 11/12/2018 | 98.58 | 99.15 | 99.3 | 99.61 | 26008 | 81.1 | 107.73 | 28184 | 70.81 | 75.63 | 28909 | 67.51 | 79.62 | 25469 | 75.86 | 90.78 |
| 12/12/2018 | 98.95 | 99.35 | 99.38 | 99.74 | 29616 | 74.21 | 84.86 | 32407 | 66.94 | 78.02 | 31932 | 64.03 | 67.46 | 29017 | 72.2 | 78.33 |
| 13/12/2018 | 98.99 | 99.41 | 99.54 | 99.77 | 30784 | 75.22 | 82.34 | 33884 | 67.05 | 75.15 | 33319 | 63.1 | 65.01 | 31091 | 73.34 | 77.45 |
| 14/12/2018 | 99.01 | 99.48 | 99.43 | 99.66 | 26080 | 77.41 | 93.98 | 29162 | 68.76 | 71.35 | 25759 | 67.09 | 74.13 | 24384 | 75.5 | 86.14 |
| 15/12/2018 | 98.75 | 99.25 | 99.26 | 99.61 | 19272 | 77.32 | 98.11 | 21655 | 69.81 | 83.66 | 19877 | 68.14 | 84.9 | 18471 | 74.66 | 84.13 |
| **Averages** | **25979** | **77.06** | **95.28** | **29023** | **68.94** | **76.04** | **28394** | **66.6** | **75.54** | **27130** | **72.39** | **81.19** | **25979** | **77.06** | **95.28** | **29023** |

*Table 13: Daily achieved compliance and the daily average location error (in m) for all spectral bands in the period 16/11/2018 – 15/12/2018.*

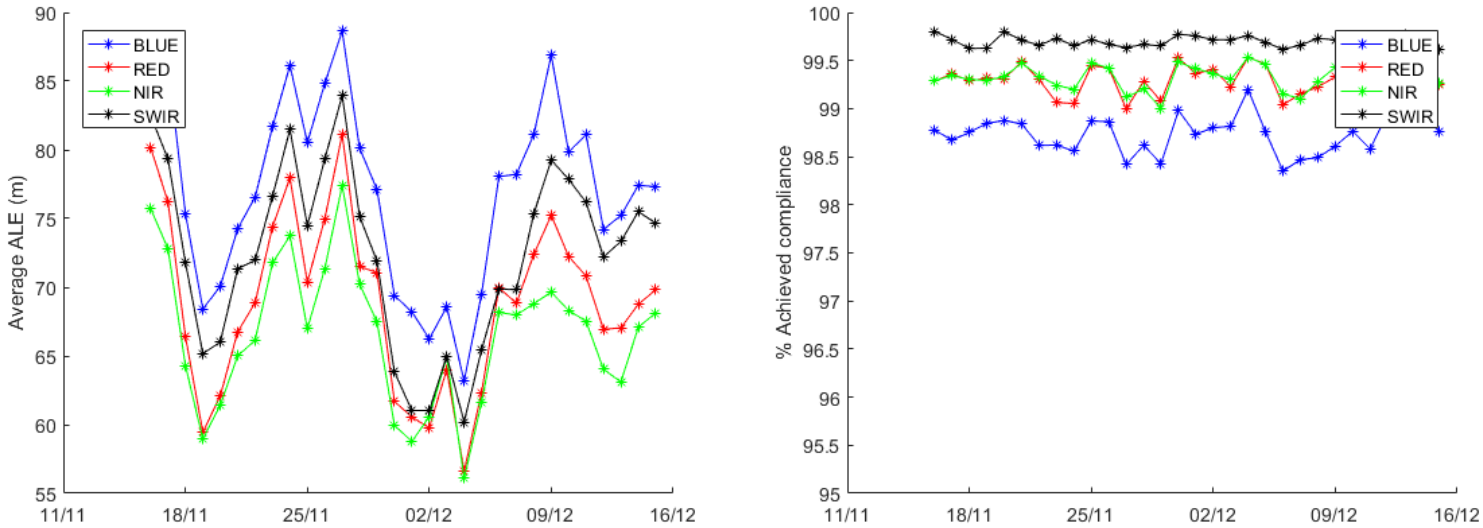



*Figure 20: Daily average location error in the period from 16/11/2018 – 15/12/2018 (left) and the average daily compliance of all spectral bands (right).*

## 2.3.2. Inter-band geometric accuracy

The monthly average inter-band geolocation error for all spectral band combinations was as follows:

| Band pair | Inter-band error [m] |
|---|---|
| BLUE-RED | 33.79, σ = 9.65 |
| BLUE-NIR | 49.82, σ = 15.65 |
| BLUE-SWIR | 51.86, σ = 16.12 |
| RED-NIR | 34.09, σ = 12.92 |
| RED-SWIR | 43.36, σ = 13.45 |
| NIR-SWIR | 41.48, σ = 10.77 |

*Table 14: Inter-band geolocation accuracy for period 16/9/2018 to 15/10/2018 for the combined cameras, at 95% confidence level.*

| Band pair | Inter-band error [m] |
|---|---|
| BLUE-RED | 35.56, σ = 11.00 |
| BLUE-NIR | 51.64, σ = 17.06 |
| BLUE-SWIR | 55.03, σ = 17.01 |
| RED-NIR | 36.10, σ = 16.52 |
| RED-SWIR | 45.07, σ = 12.45 |
| NIR-SWIR | 42.09, σ = 8.00 |

*Table 15: Inter-band geolocation accuracy for period 16/10/2018 to 15/11/2018 for the combined cameras, at 95% confidence level.*

| Band pair | Inter-band error [m] |
|---|---|
| BLUE-RED | 35.86, σ = 9.29 |
| BLUE-NIR | 54.66, σ = 21.08 |
| BLUE-SWIR | 58.18 σ = 19.02 |
| RED-NIR | 34.04, σ = 15.32 |
| RED-SWIR | 45.55, σ = 9.82 |
| NIR-SWIR | 45.24, σ = 8.56 |

*Table 16: Inter-band geolocation accuracy for period 16/11/2018 to 15/12/2018 for the combined cameras, at 95% confidence level.*

For the combined cameras, the inter-band geometric accuracy range was 34 – 55 m (standard deviation range is 8 – 21 m), which is 0.10 – 0.17 of a pixel (333 m). The average inter-band RED-NIR registration accuracy was 35 m, which is 1 m higher than previous reporting period.

## 2.3.3. Multi-temporal geometric accuracy

During this reporting period the multi-temporal compliance of the geometric accuracy was:

- 52.82% for the VNIR sensor (171225 GCPs used),
- 74.00% for the VNIR/SWIR combined (196876 GCPs used).

The multi-temporal sensor compliance has decreased by 30.34% for the VNIR sensor and decreased by 21.1% for the combined VNIR/SWIR sensors, compared to the previous reporting period (in which values were 83.16% and 95.10%, respectively). This is a significant decline in multi-temporal compliance and we will closely monitor its evolution during the next quarter.

For the VNIR the multi-temporal geometric accuracy is below the requirements. A map of regions with decreased multi-temporal geometric accuracy is presented in

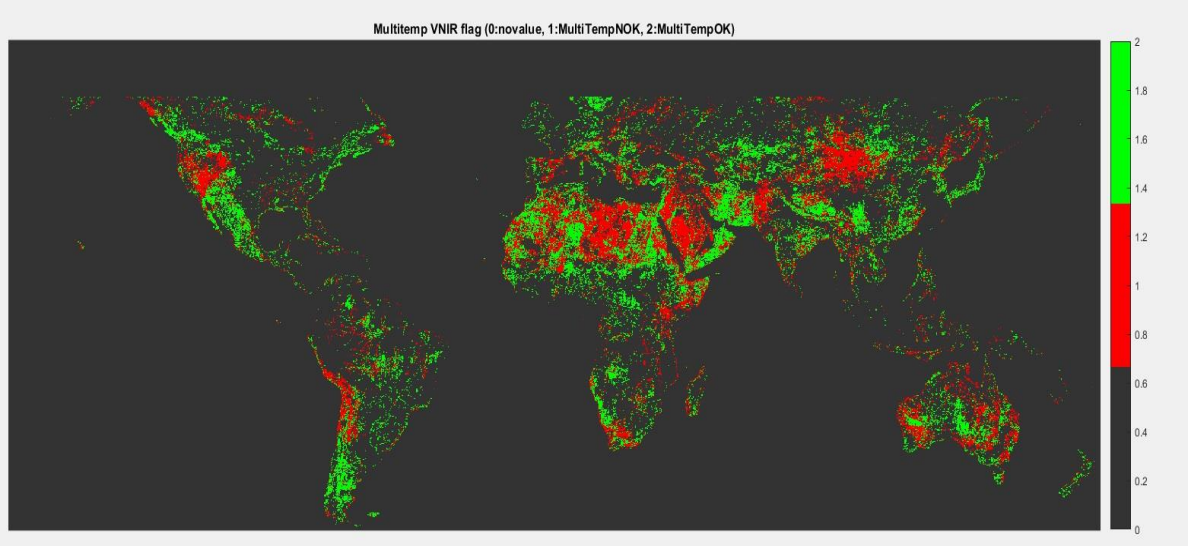



Figure 21.

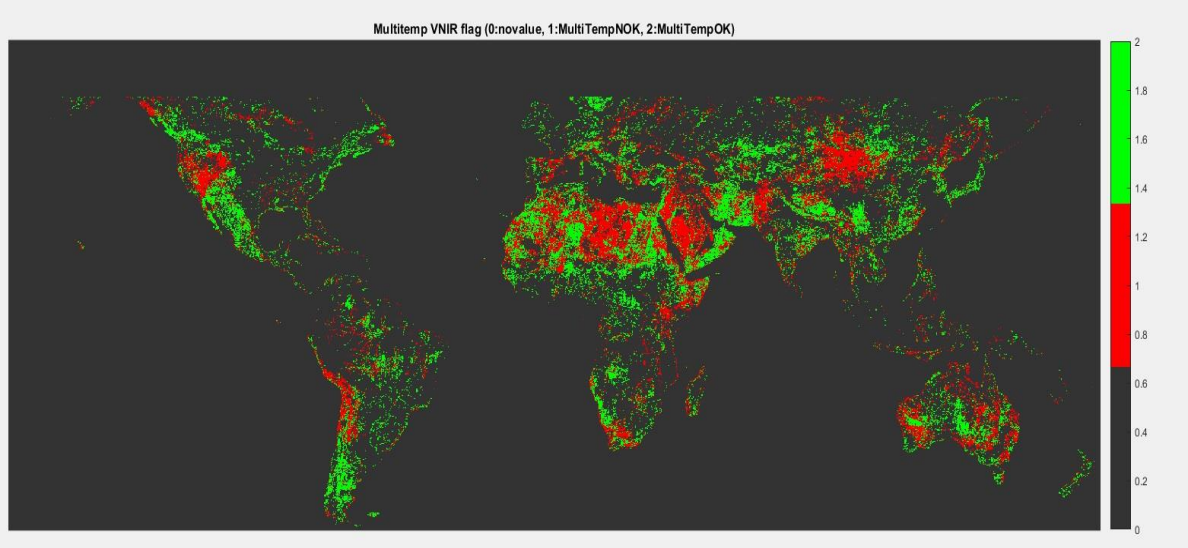



*Figure 21: Multi-temporal geometric accuracy for the VNIR sensor for 16/9/2018 – 15/12/2018. Compliant areas are marked in green; areas with accuracy below 95% are marked in red. Grey areas represent no data.*

*For the combined VNIR/SWIR the multi-temporal geometric accuracy is compliant with the requirements. A map of regions with decreased multi-temporal geometric accuracy is presented in*

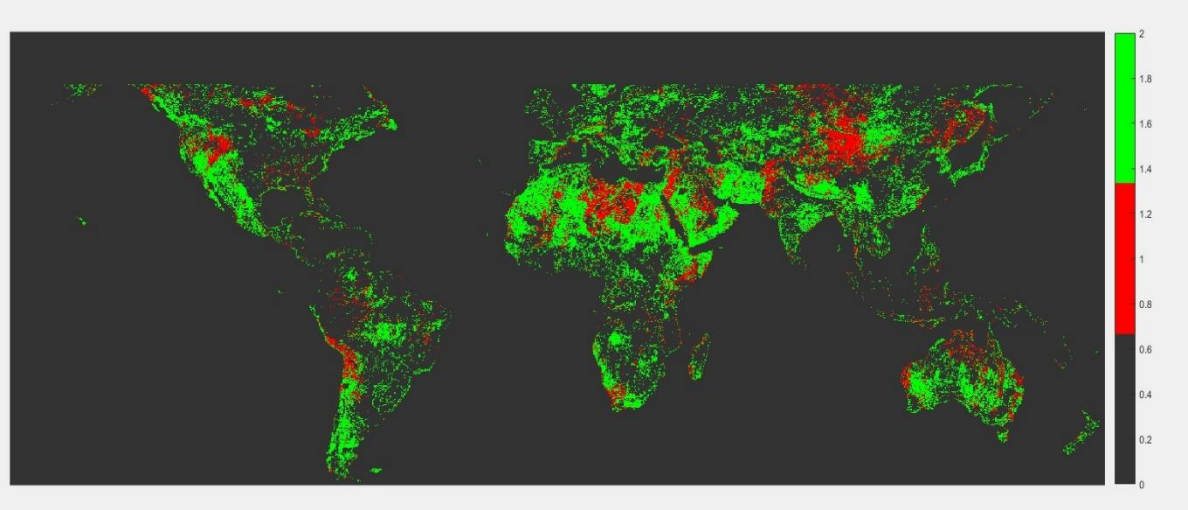



Figure 22.

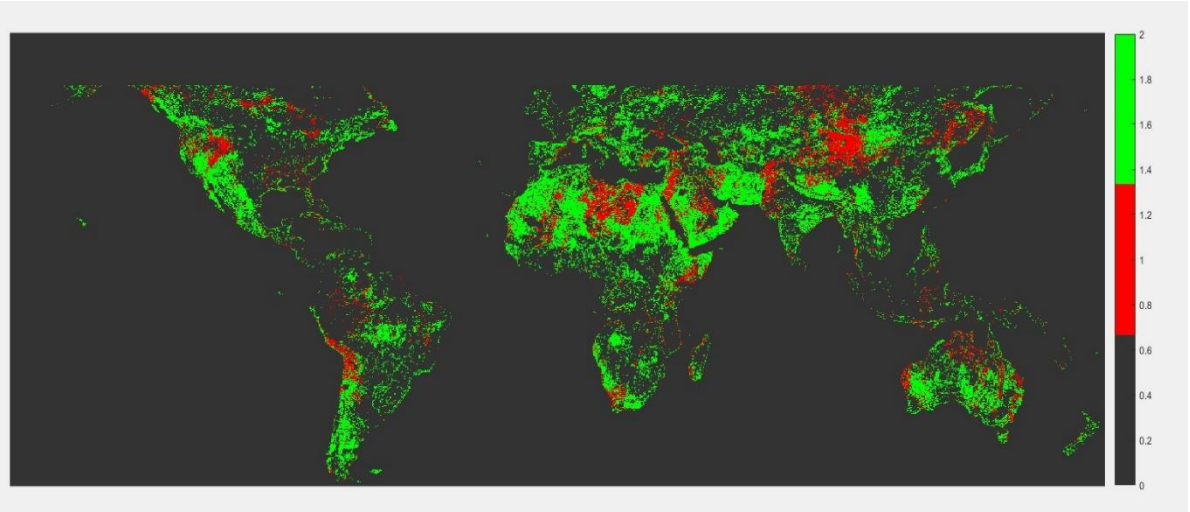



*Figure 22: Multi-temporal geometric accuracy for the VNIR/SWIR combined for 16/9/2018 – 15/12/2018.. Compliant areas are marked in green; areas with accuracy below 95% are marked in red. Grey areas represent no data.*

Over the last full year, the multi-temporal accuracy for VNIR and VNIR/SWIR is 74.66% and 89.54%, respectively.

## 2.4. Geometric ICP file

On 08.09.2016 a new file with validity date set to 01.09.2016 was created.

| ICP filename | Description |
|---|---|
| PROBAV_ICP_GEOMETRIC#LEFT_20160901_V01<br>PROBAV_ICP_GEOMETRIC#CENTER_20160901_V01<br>PROBAV_ICP_GEOMETRIC#RIGHT_20160901_V01 | Correction for the gradual degradation observed in the last week of August and first week of September 2016. |

# 3. Reference documents

| | |
|---|---|
| **RD-1** | PROBA-V Commissioning Report Annex 1-Radiometric Calibration Results [N77D7-PV02-US-20-CRPT-Annex1-RadiometricCalibartion-v1_3] |
| **RD-2** | PROBA-V Commissioning Report Annex 2-Geometric Calibration Results [N77D7-PV02-US-20-CRPT-Annex2-GeometricCalibartion-v1_3] |
| **LIT1** | Govaerts Y., Sterckx S. and Adriaensen S. (2013) "Use of simulated reflectances over bright desert target as an absolute calibration reference" Remote Sensing Letters, Vol. 4, Iss. 6, 2013. |
| **LIT2** | S. Adriaensen, K. Barker, L. Bourg , M. Bouvet, B. Fougnie, Y. Govaerts, P. Henry, C. Kent, D. Smith, S. Sterckx. "CEOS IVOS Working Group 4: Intercomparison of vicarious calibration methodologies and radiometric comparison methodologies over pseudo-invariant calibration sites A Report to the CEOS/IVOS Working Group", 2012 |
| **LIT3** | Sterckx S., Adriaensen S., Livens, L., "Rayleigh, Deep Convective Clouds and Cross Sensor Desert vicarious calibration validation for the PROBA-V mission." IEEE Transactions on Geoscience and Remote Sensing. Inter-Calibration of Satellite Instruments Special Issue. Vol.51:3, 1437 – 1452. |

*Table 18: Reference Documents*