proba-v

QUARTERLY IMAGE QUALITY REPORT

IQR#029

Reporting period from 16/12/2020 to 15/03/2021

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1. Radiometric Image Quality

1.1. Summary

We observe very strong seasonal variations in the Libya-4 results for mainly the RIGHT camera. We assume that this might be due to uncertainties in the OSCAR desert model combined with the orbital drift of PROBA-V. This is not observed for the CENTER camera, while the LEFT camera a slight increasing trend is observed.

There are 4 new bad pixels identified in this reporting period.

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.

A trend-break in the the Libya-4 results for the RIGHT camera is observed: while over the last two years a clear positive trend was observed, a "sudden drop" is seen now since about 3 months. This might be linked to the orbital drift causing larger BRDF related seasonal changes not fully accounted for in the modelling.

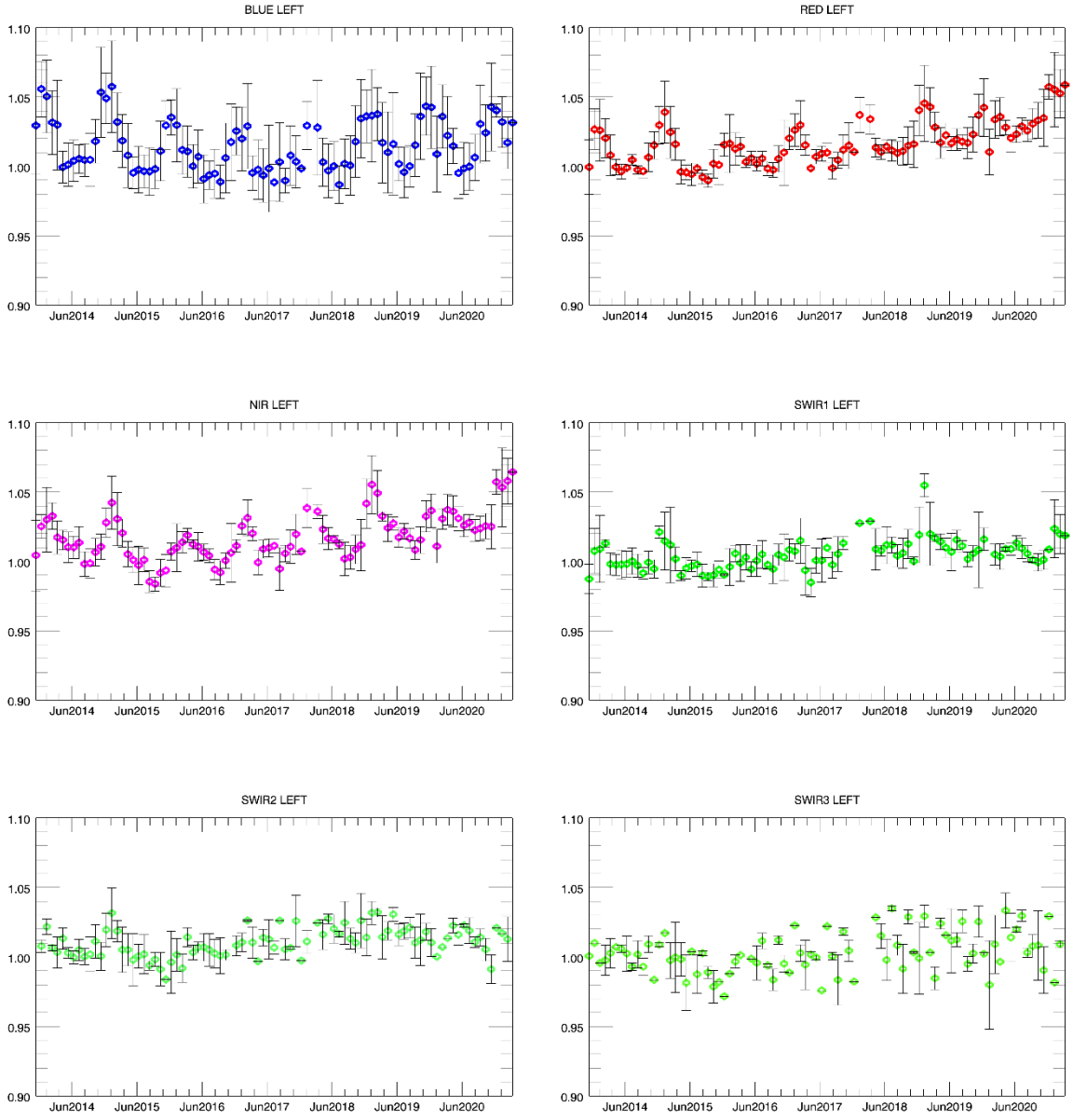


Figure 1. Libya-4 desert calibration results: LEFT monthly averaged results (Collection 1)

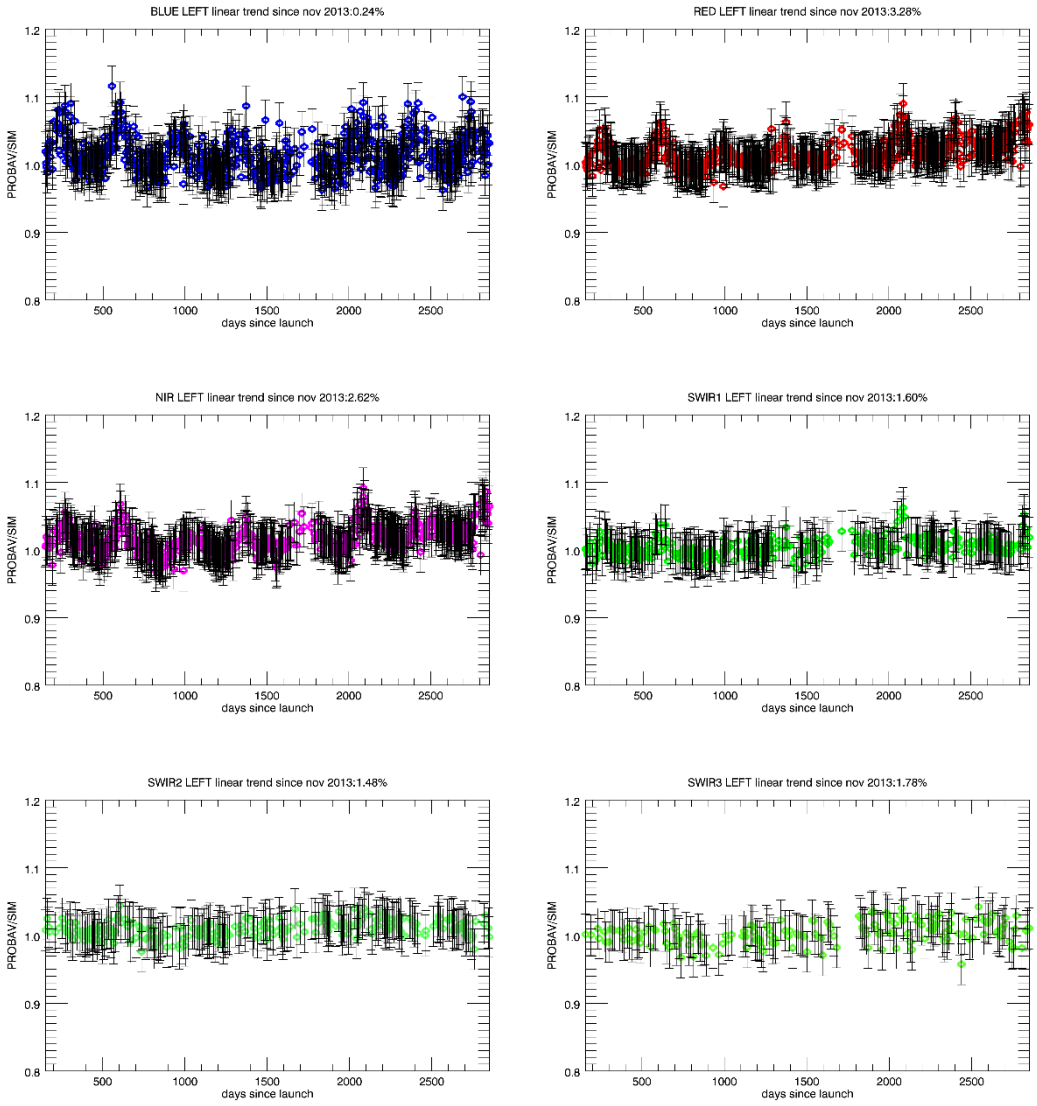


Figure 2. Libya-4 desert calibration results: LEFT individual results (Collection 1)

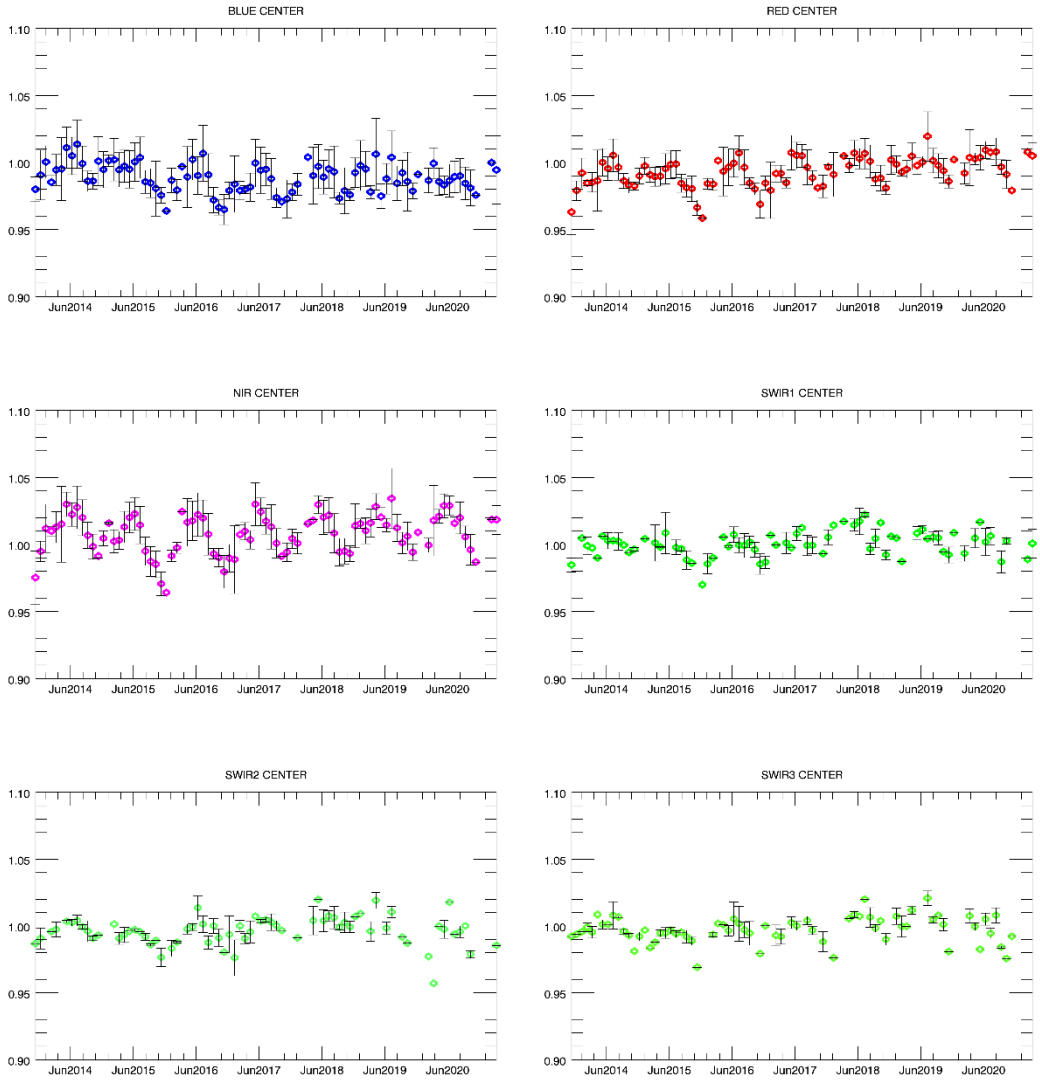


Figure 3. Libya-4 desert calibration results: CENTER monthly averaged results (Collection 1)

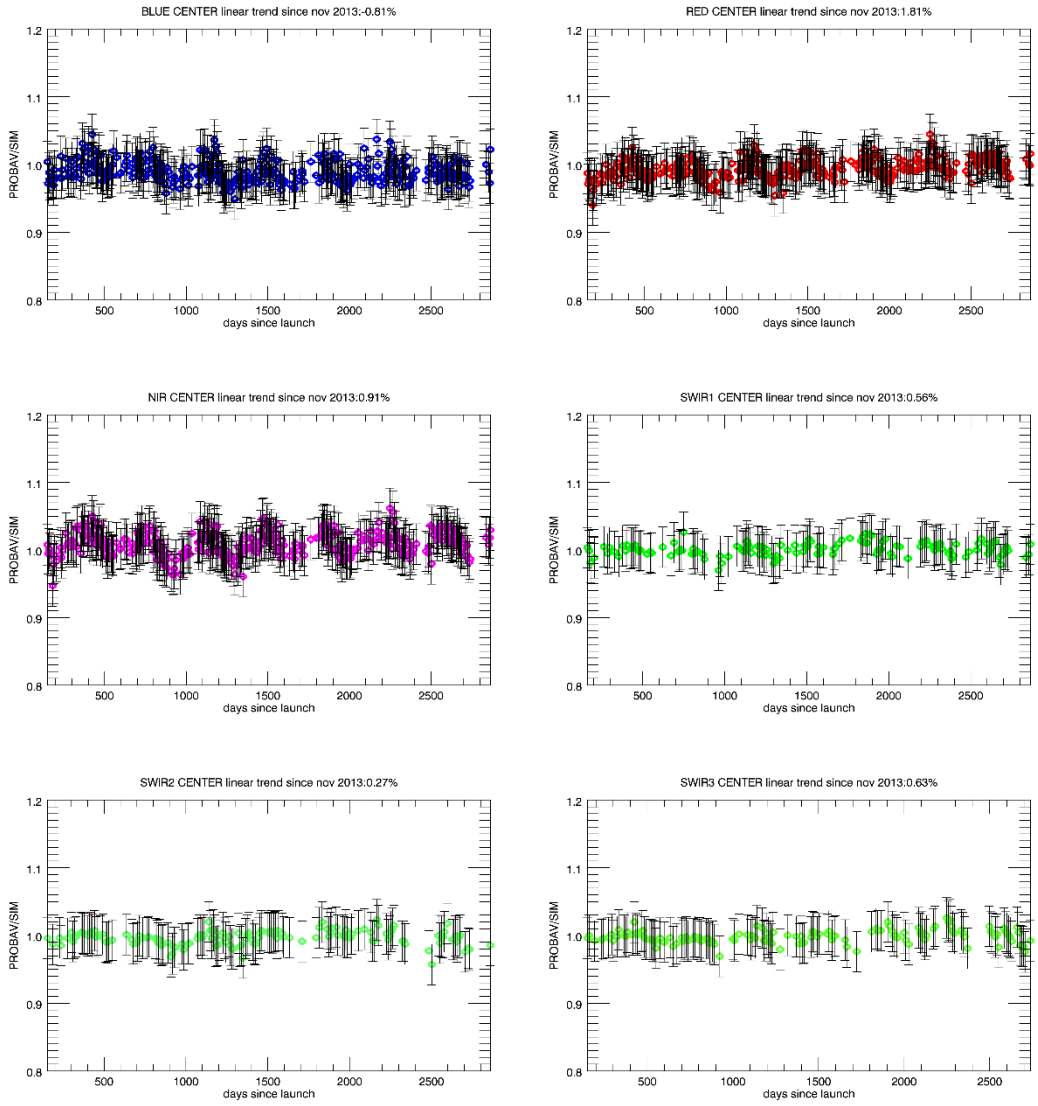


Figure 4. Libya-4 desert calibration results: CENTER individual results (Collection 1)

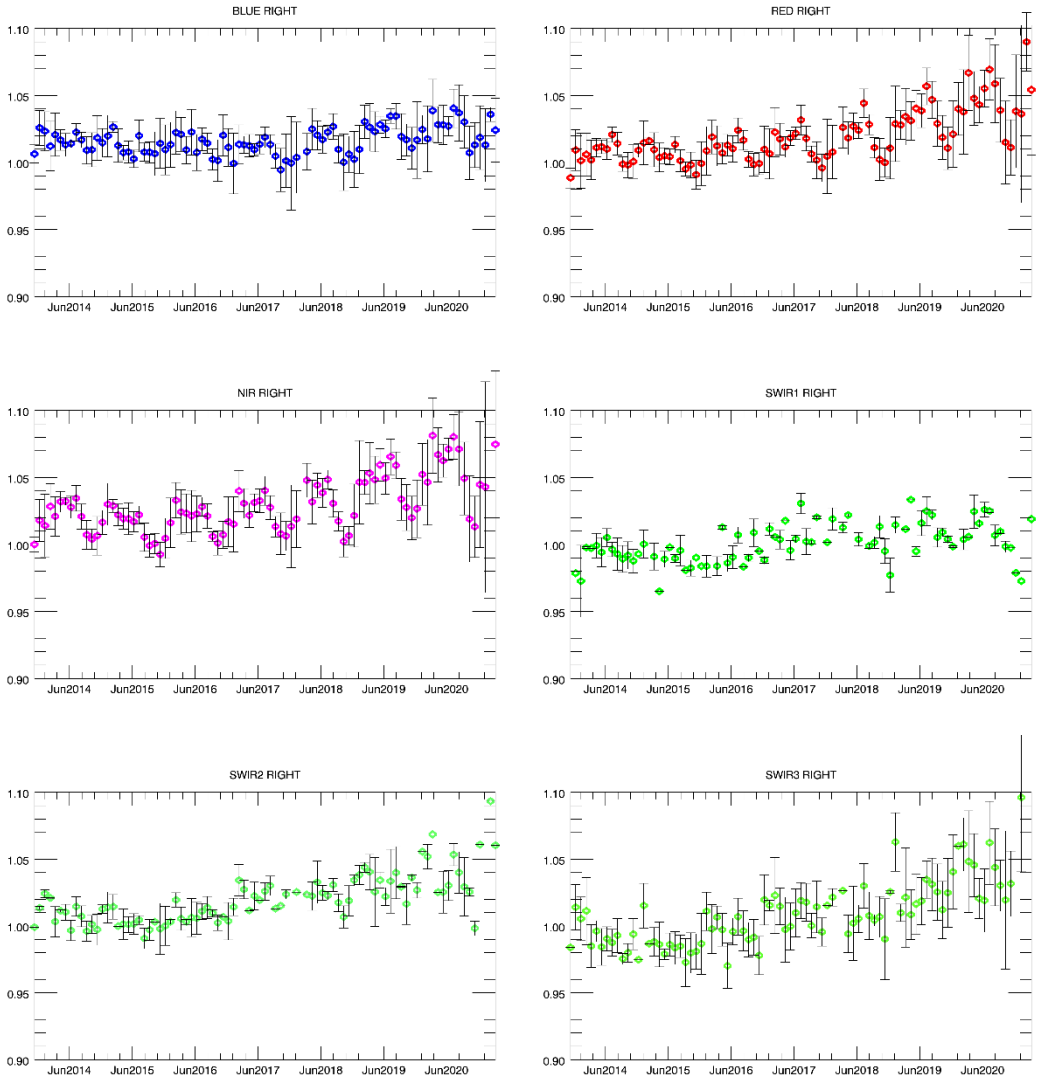


Figure 5. Libya-4 desert calibration results: RIGHT monthly averaged results (Collection 1)

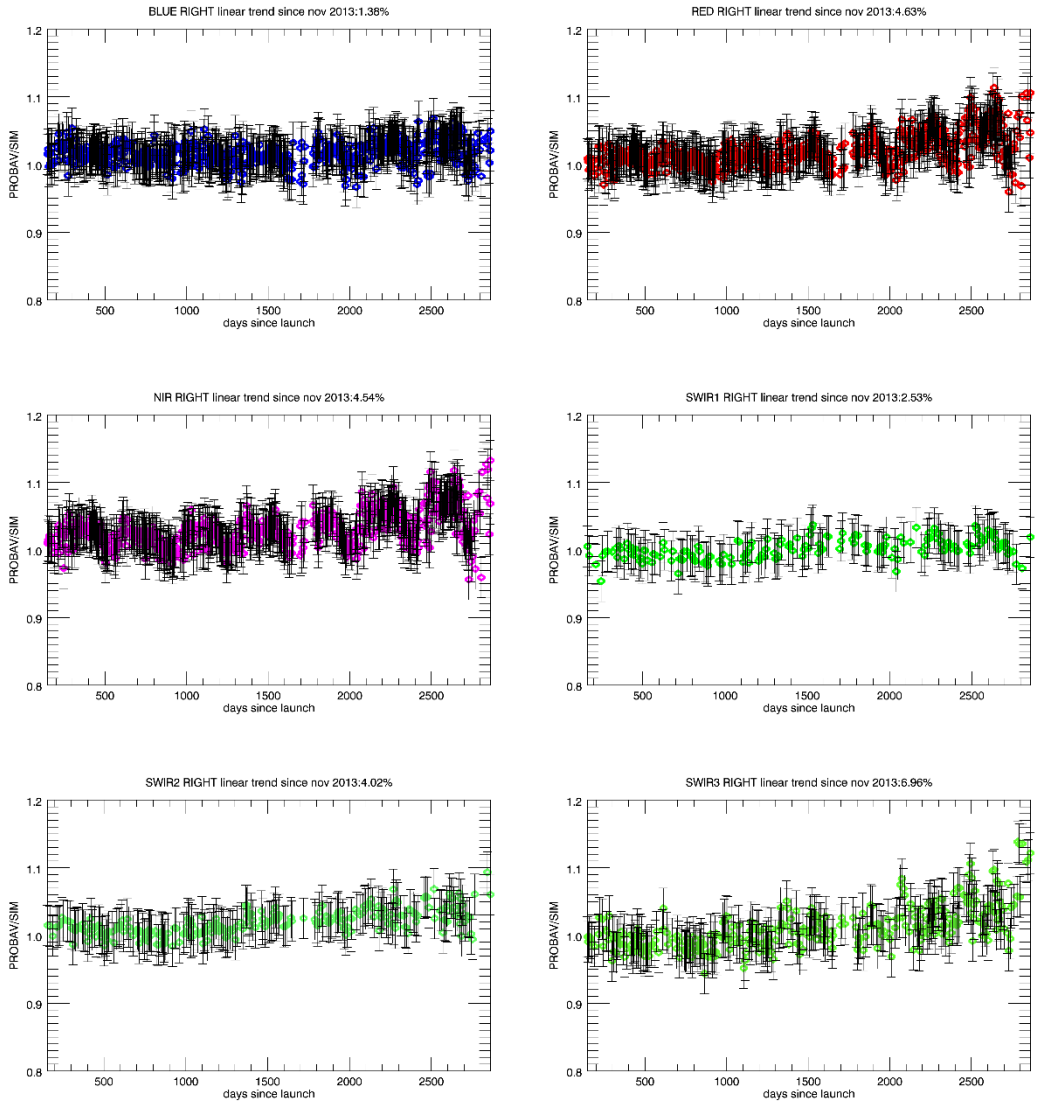


Figure 6. Libya-4 desert calibration results: RIGHT individual results (Collection 1)

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.

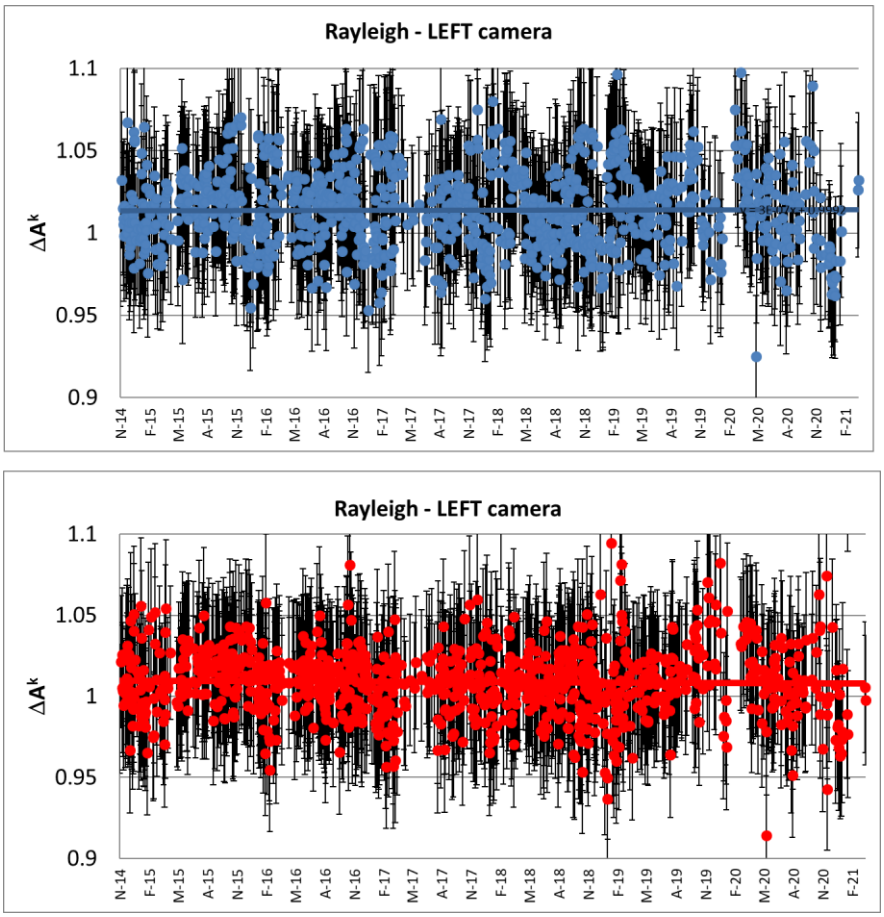


Figure 7. Rayleigh absolute calibration results: LEFT camera (Collection 1)

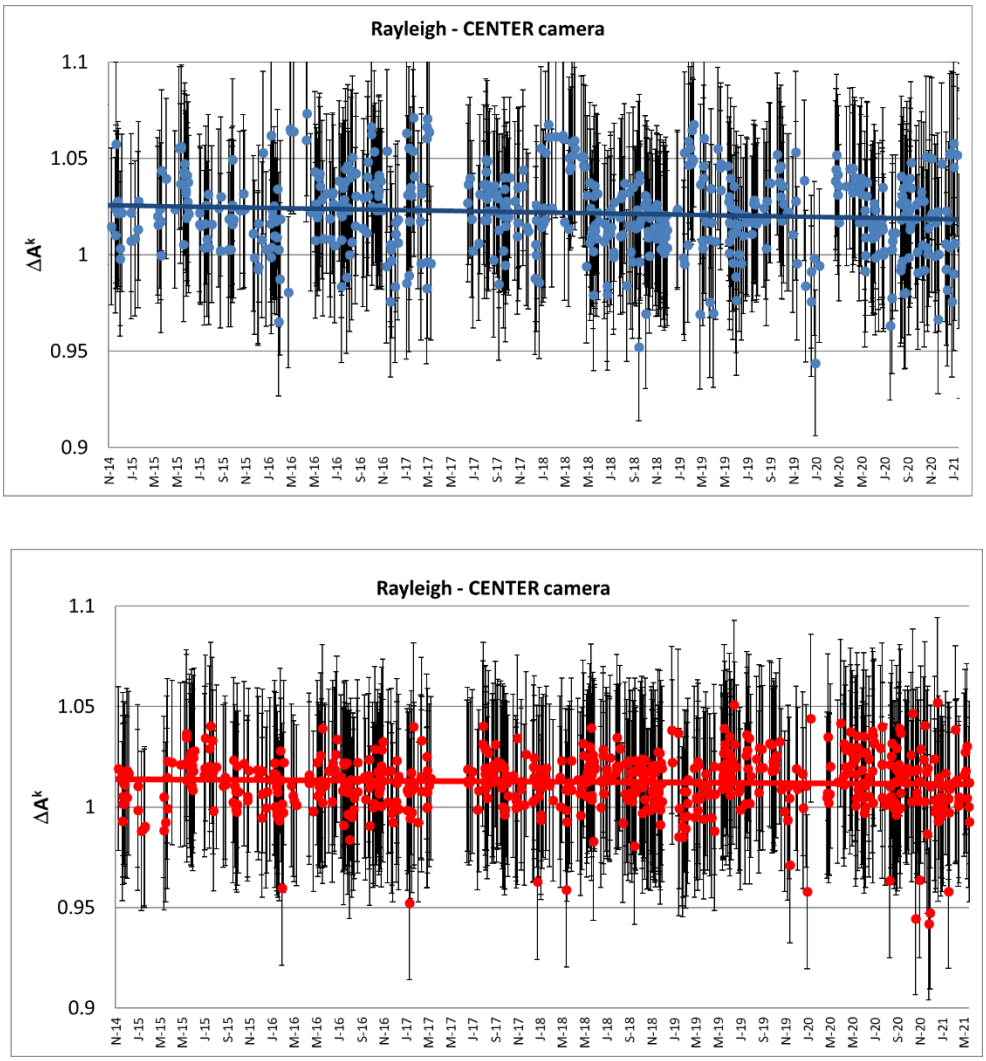
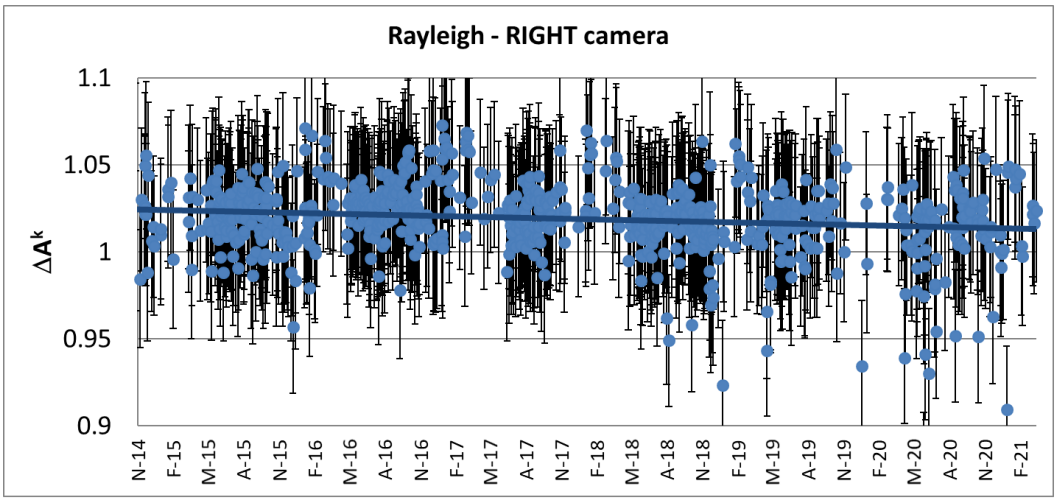


Figure 8. Rayleigh absolute calibration results: CENTER camera (Collection 1)



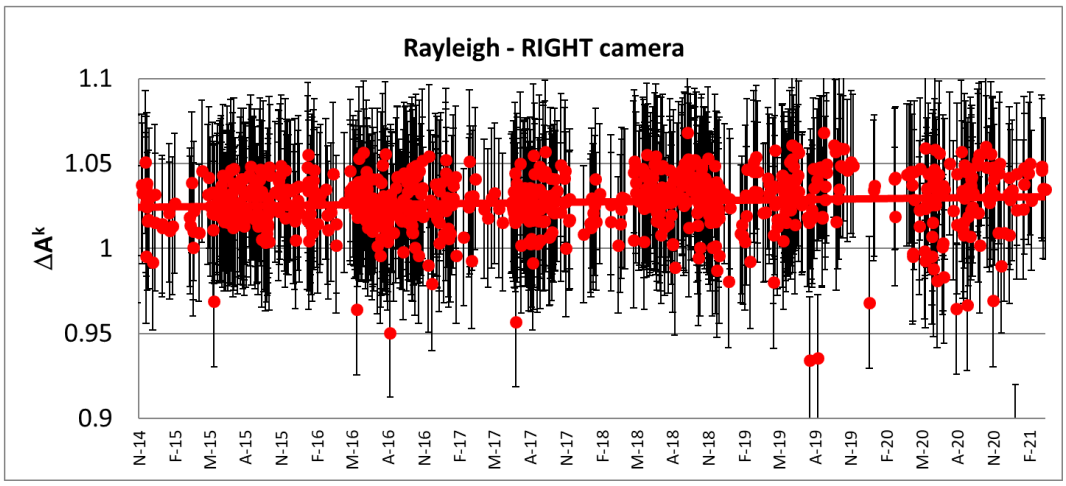


Figure 9. Rayleigh absolute calibration results: RIGHT camera (Collection 1)

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 2020) is given in Figure 10 for all cameras using the **collection 1 ICP files**.

The DCC calibration results show a decrease in responsivity of the BLUE bands of all cameras, even after May 2017 when the degradation model for BLUE LEFT/CENTER strips was implemented (see 1.2.4). This trend is much larger than the slight negative trend observed in the Libya-4 BLUE LEFT/CENTER calibration data. The trend observed in the DCC BLUE band results is thought to be due to the the increase of responsivity in the RED band as observed in the Libya-4 results for all cameras as well as in the moon calibration results for the CENTER camera. As the BLUE band DCC results, are inter-band calibration results, expressed relatively to the RED band, an increase in responsivity of the RED band (and not for the BLUE band) will result in a decrease of the BLUE band DCC inter-band calibration results.

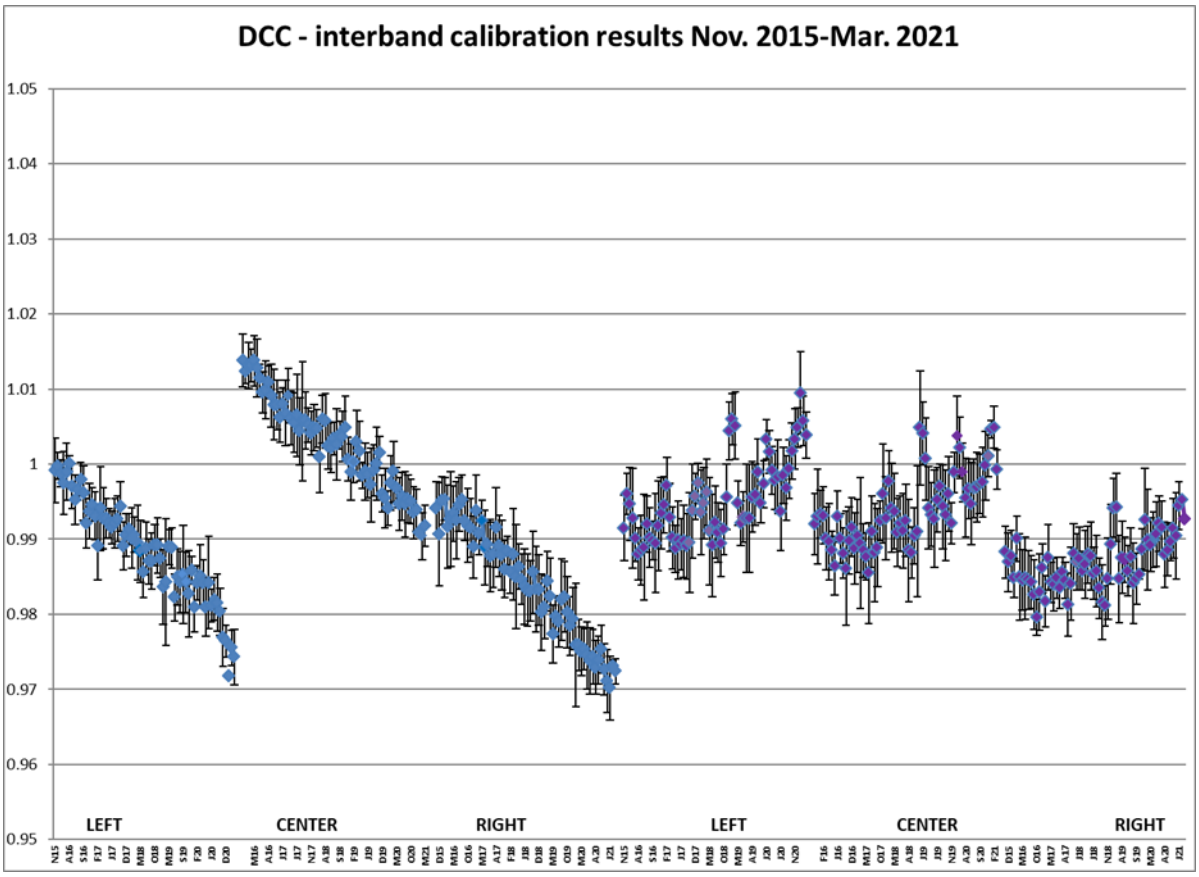
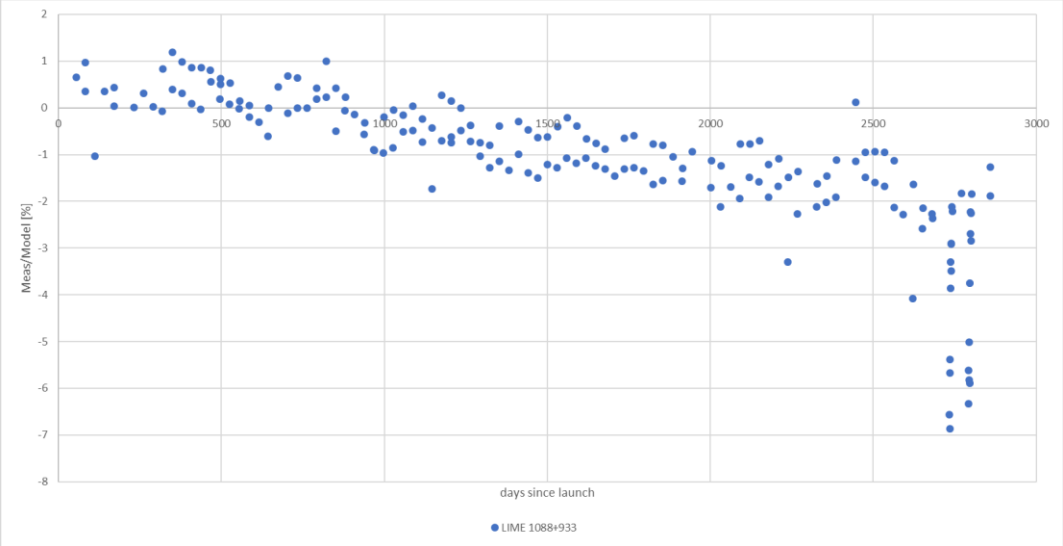


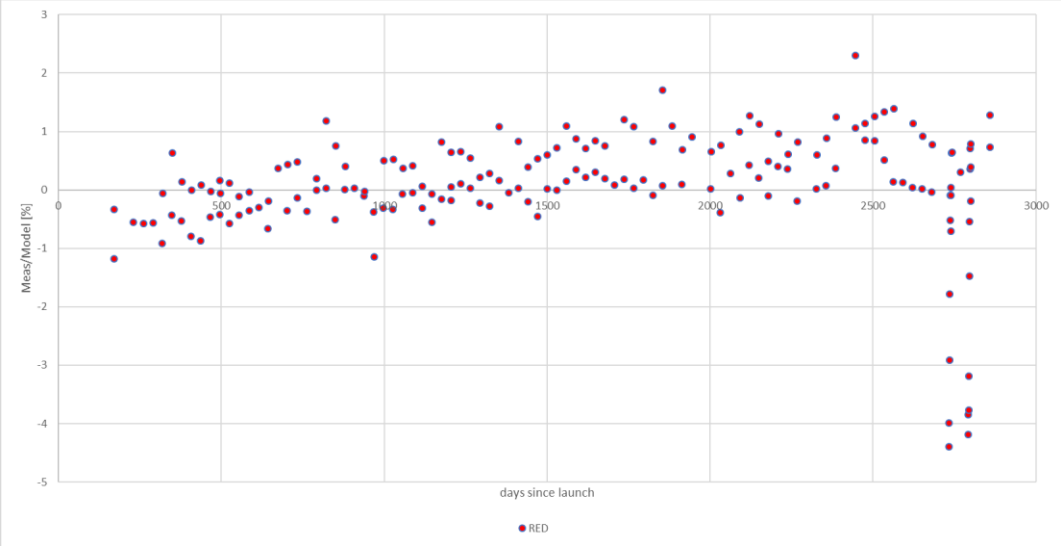
Figure 10. DCC inter-band calibration results: LEFT, CENTER and RIGHT camera

1.2.3. PROBA-V Multi-temporal Lunar calibration results

The Lunar calibration results for the VNIR CENTER camera bands are given in Figure 11. The results are given based on the **collection 1 ICP** files. In each plot the results are given on basis of the new LIME model being developed within the ESA lunar irradiance project based on upon lunar measurements acquired with the CE318-TP9 instrument.

Over the entire mission the BLUE band lunar calibration results show a decreasing trend while for the RED and NIR a decreasing trend is observed. This is in line with the observations over the Libya-4 desert. The 'outlier' lunar calibration results are experimental acquisitions performed at different phase angles.





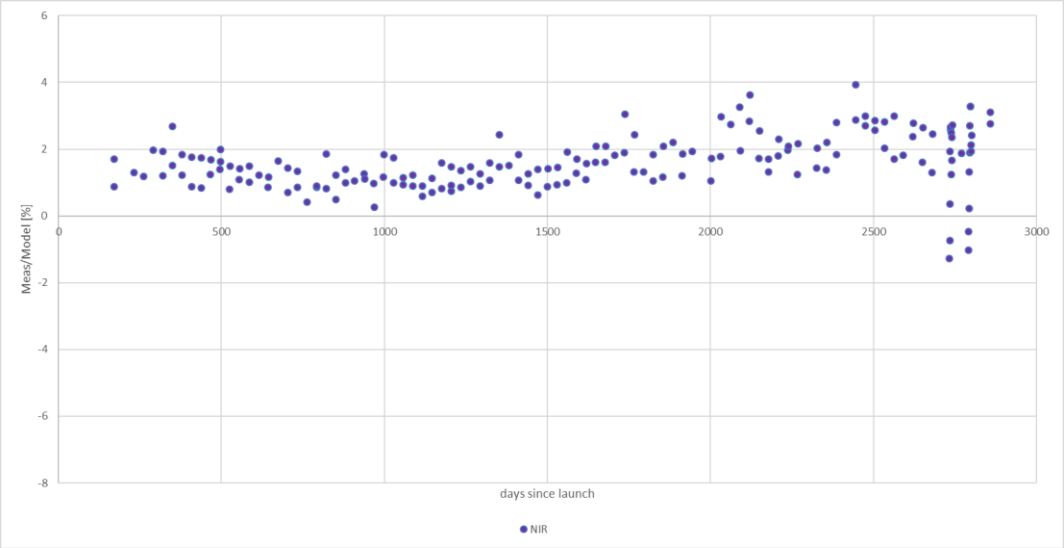


Figure 11. Lunar Calibration results CENTER camera based on the LIME model

1.2.4. 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. Once ICP files are updated for the non-uniformities as quantified on the basis of the yaw maneuver, the Libya-4 desert results will be reprocessed in order to better quantify the degradation for the various SWIR strips and to re-evaluate the degradation model for the SWIR strips to be used in the reprocessing (collection 2).

In Table 1 the applied degradation model correction is given. This linear degradation 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

1.3. 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 13,Figure 14 and Figure 15 for respectively LEFT, CENTER and RIGHT camera.

Please not that in November only one dark current acquisition has been performed (on 1 November). Therefore no statistics are given for November 2020.

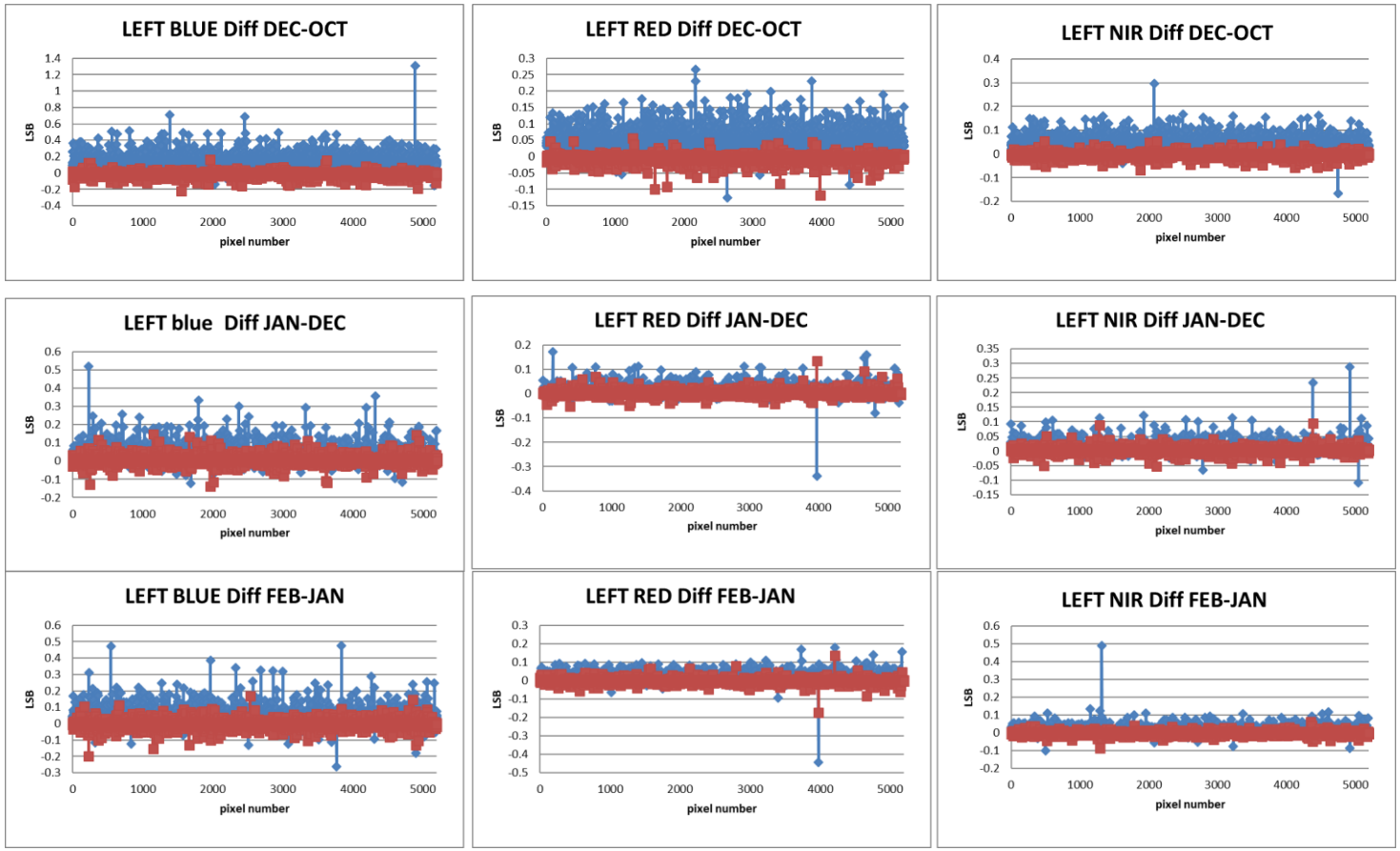


Figure 12. LEFT camera VNIR: Monthly difference (OCT2020-FEB2021) in dark current (Blue) and standard deviation (Red)

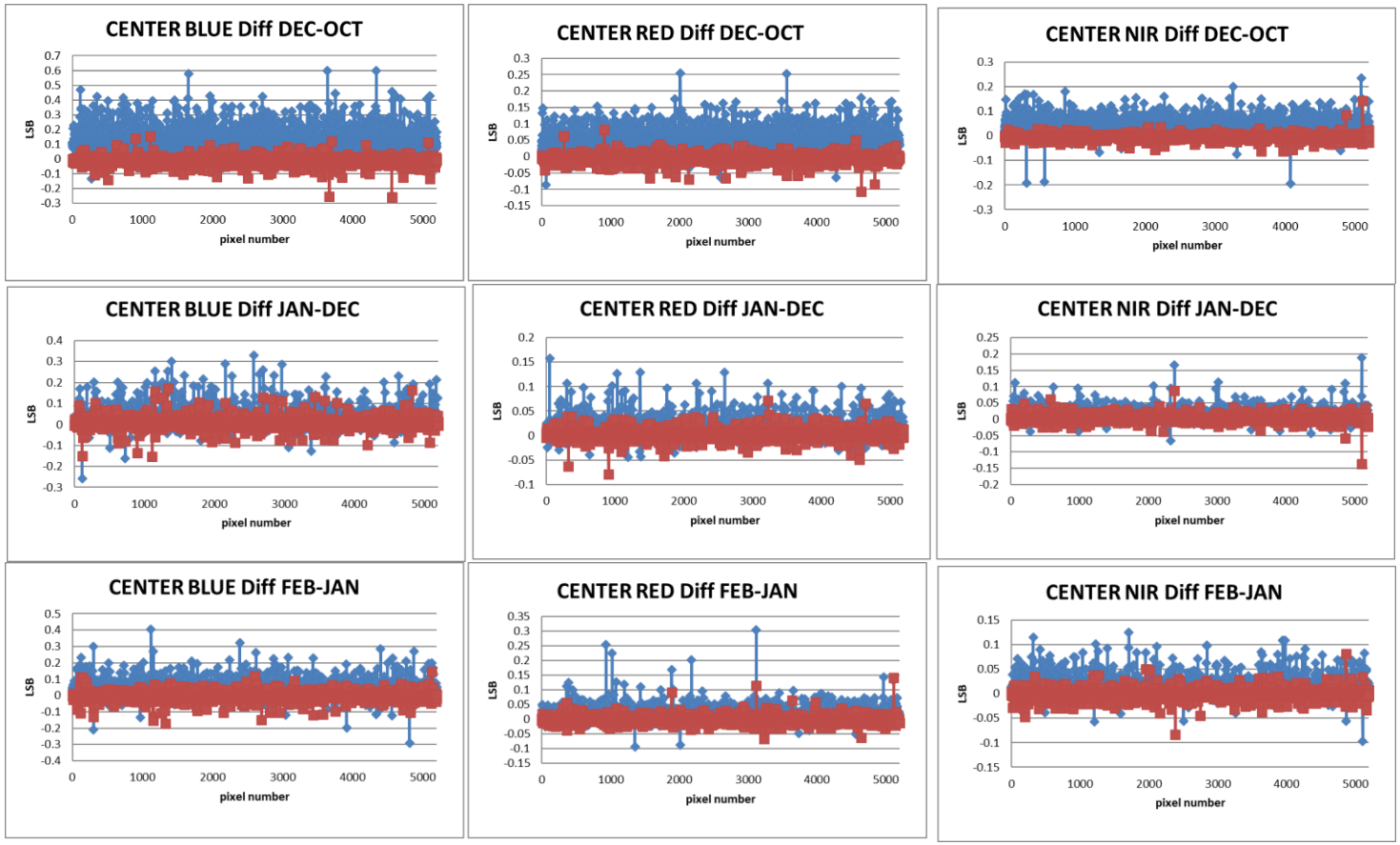


Figure 13. CENTER camera VNIR: Monthly difference (OCT2020-FEB2021*) in dark current (Blue) and standard deviation (Red) of the monthly averaged results.*

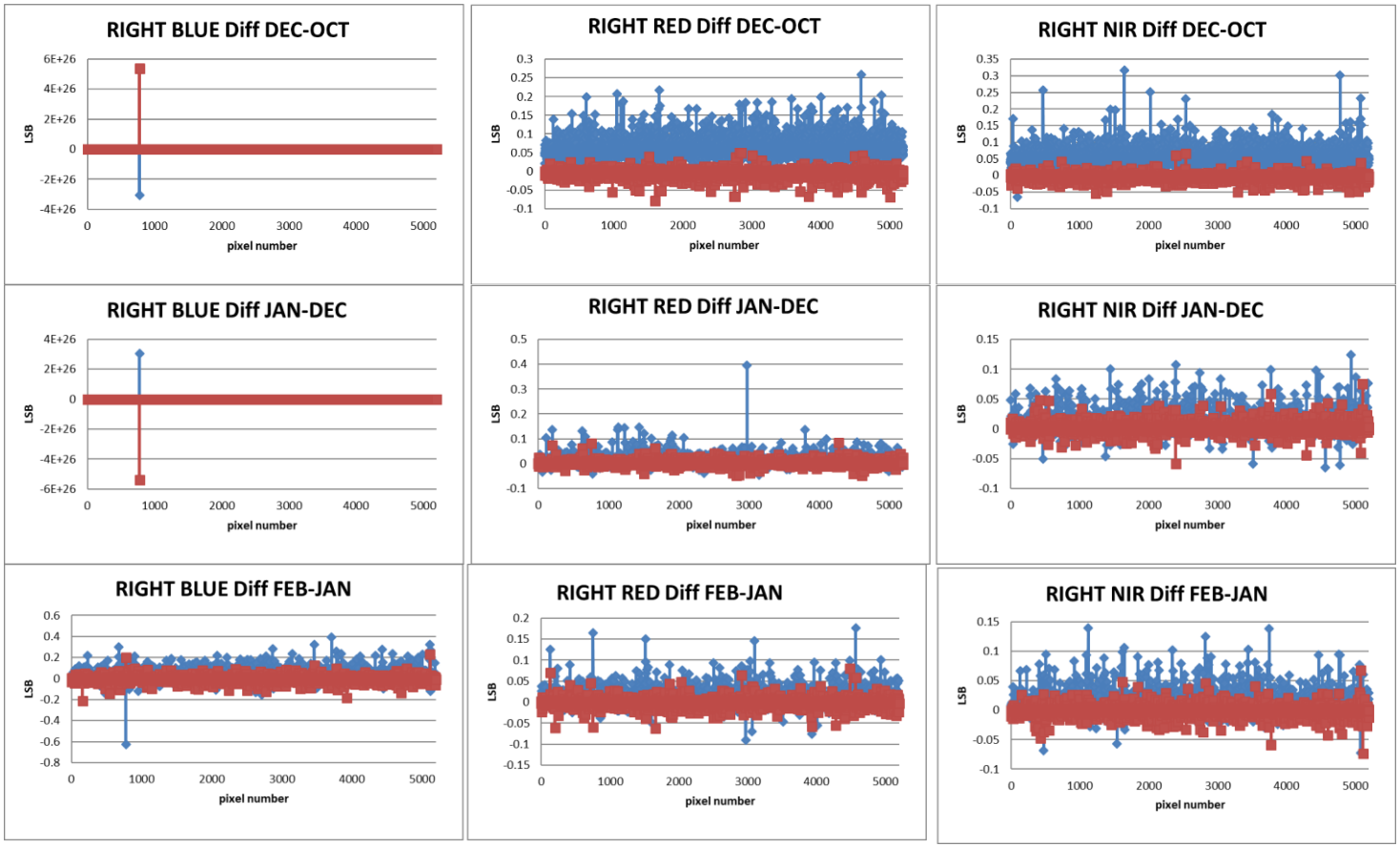


*Figure 14. RIGHT camera VNIR: Monthly difference (*OCT2020-FEB2021*) in dark current (Blue) and standard deviation (Red) of the monthly averaged results.*

1.3.3. SWIR results

Monthly difference plots for SWIR dark currents are given *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, Table 4,Table 5 the resulting SWIR dark current status during the last months is reported for respectively LEFT, CENTER and RIGHT camera.
Please not that in November only one dark current acquisition has been performed (on 1 November). Therefore no statistics are given for November 2020.

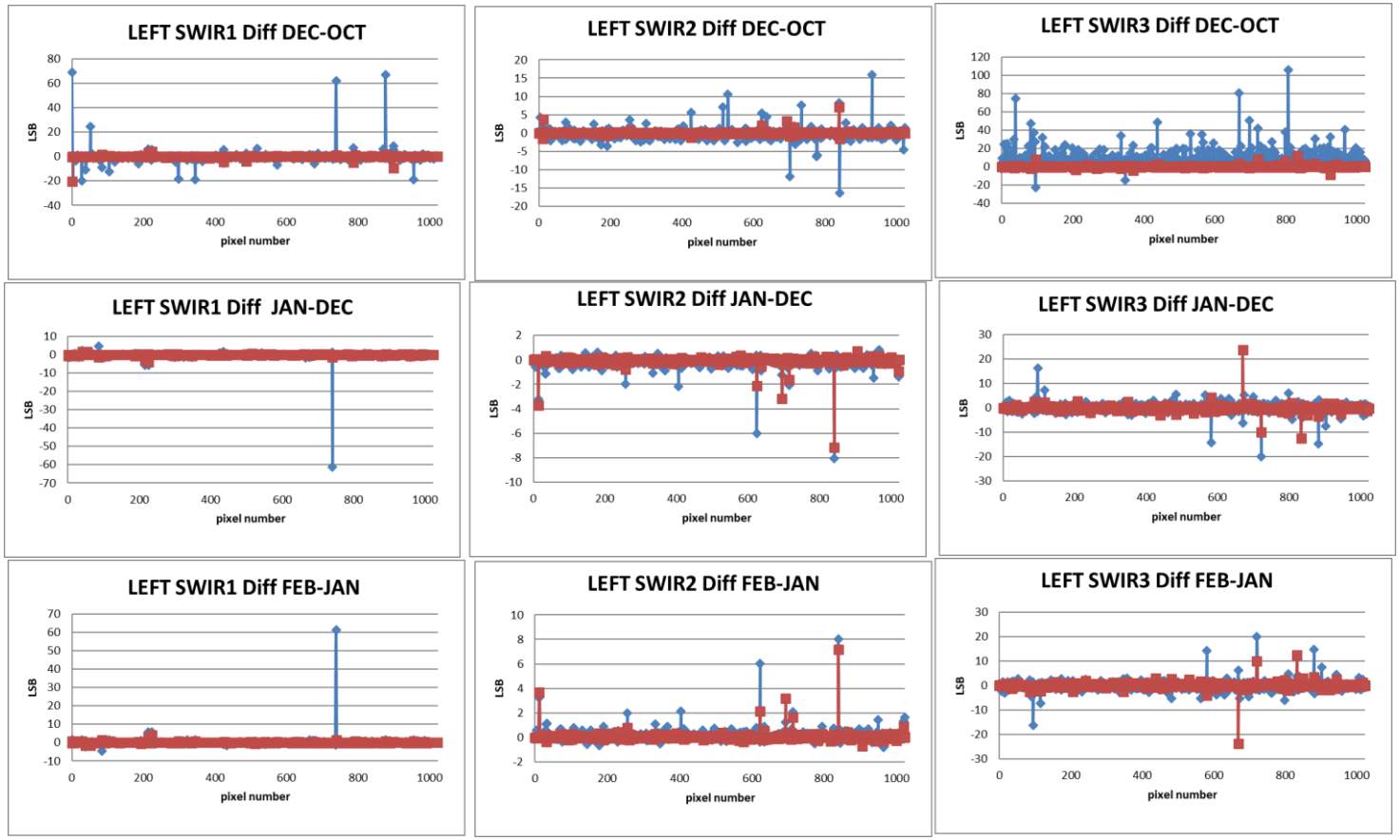


Figure 15. LEFT camera SWIR: Monthly difference (OCT2020-FEB2021) in dark current (Blue) and standard deviation (Red) of the monthly averaged results.

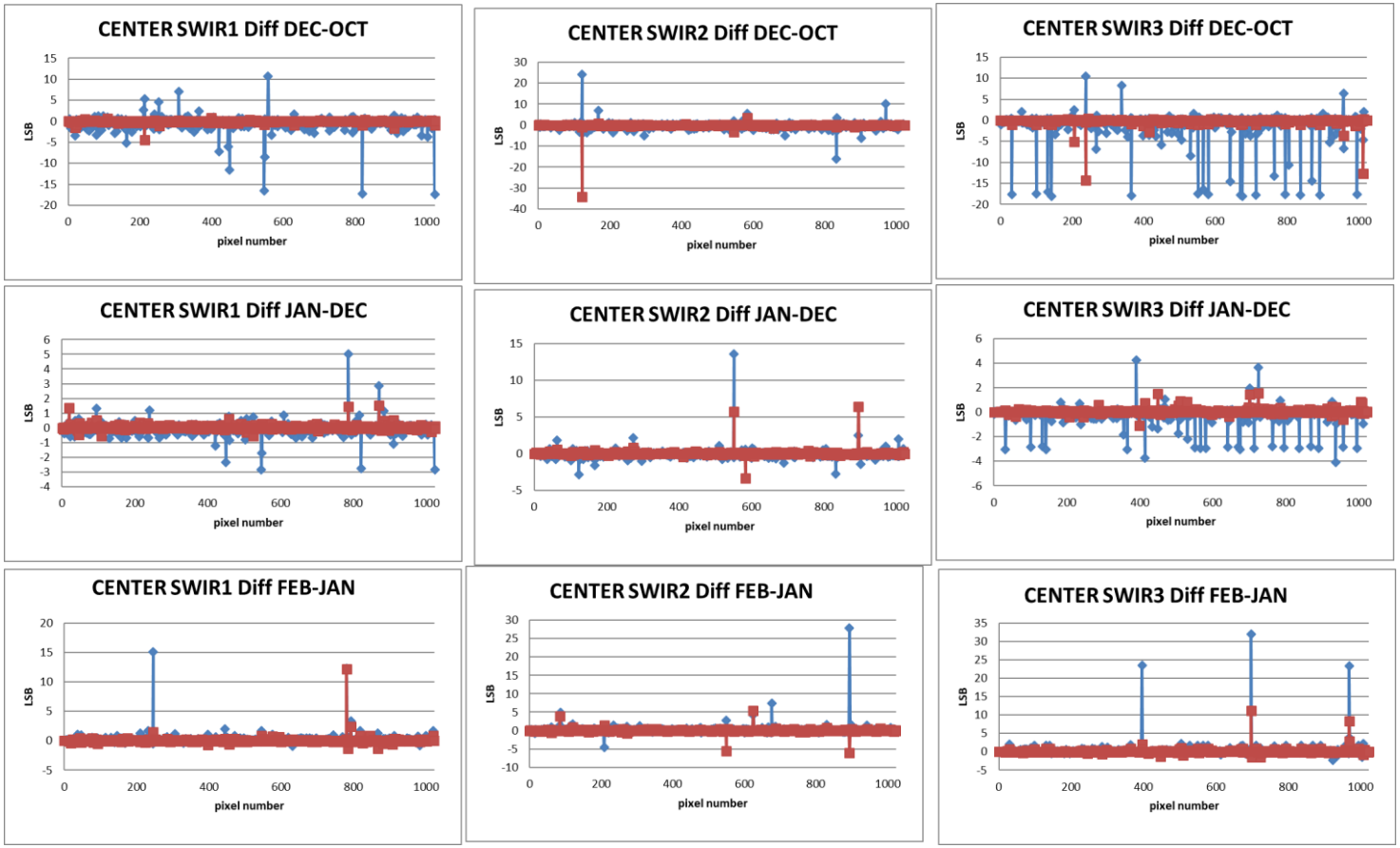


Figure 16. CENTER camera SWIR: Monthly difference (OCT2020-FEB2021) in dark current (Blue) and standard deviation (Red) of the monthly averaged results.

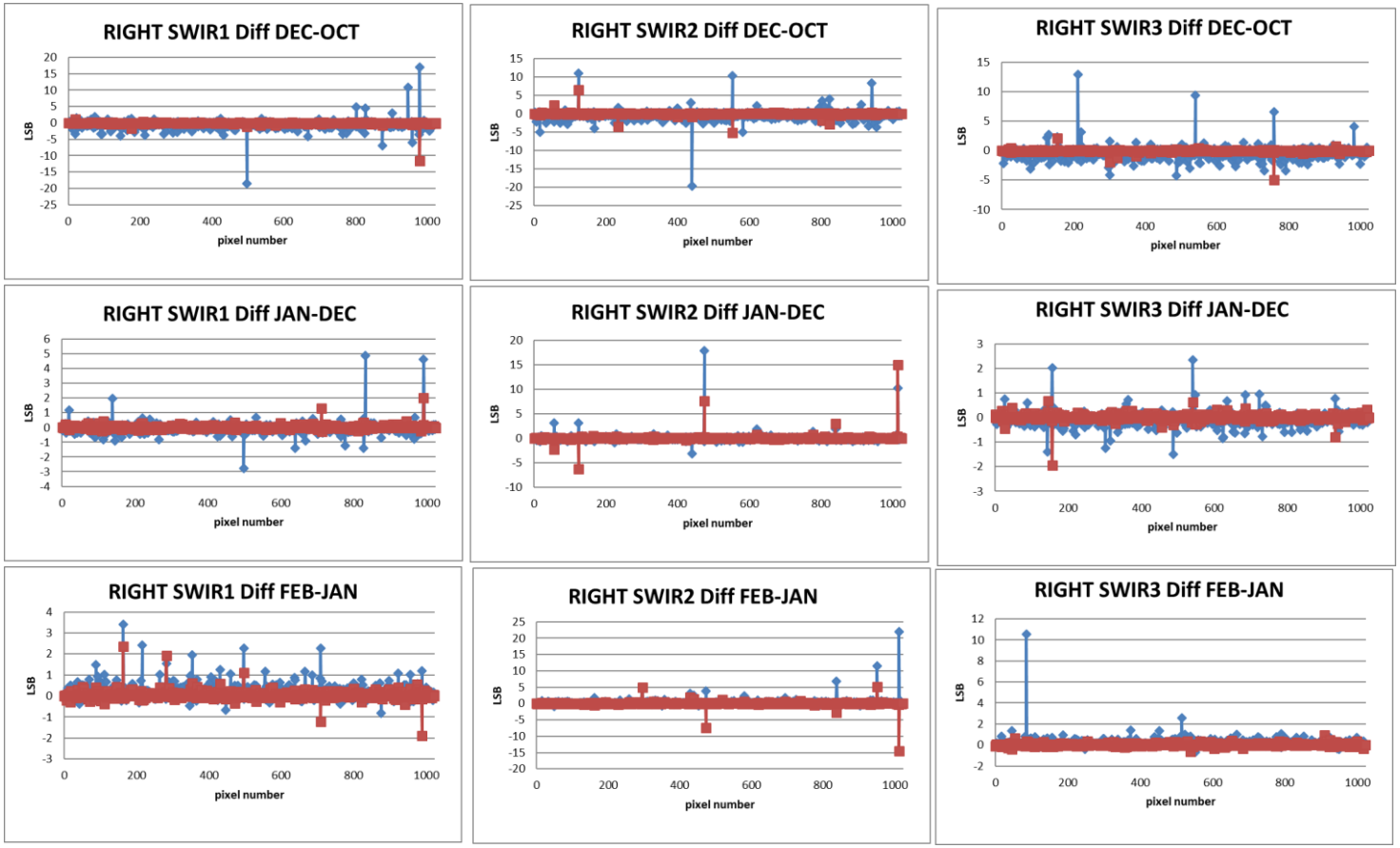


Figure 17. RIGHT camera SWIR: Monthly difference (OCT2020-FEB2021) in dark current (Blue) and standard deviation (Red) of the monthly averaged results.

SEPT-OCT-DEC						OCT-DEC-JAN						DEC-JAN-FEB					
SWIR1		SWIR2		SWIR3		SWIR1		SWIR2		SWIR3		SWIR1		SWIR2		SWIR3	
0	H DC BAD	4	H DC NOK	15	H DC BAD	84	H DC BAD	623	H DC BAD	90	H DC BAD	84	H DC BAD	623	H DC BAD	90	H DC BAD
900	H DC BAD	228	H DC NOK	34	H DC BAD	214	H DC BAD	840	H DC BAD	95	H DC BAD	214	H DC BAD	840	H DC BAD	95	H DC BAD
3	H DC NOK	426	H DC NOK	82	H DC BAD	224	H DC BAD	4	H DC NOK	115	H DC BAD	224	H DC BAD	506 pixels	H DC OK	115	H DC BAD
28	H DC NOK	515	H DC NOK	90	H DC BAD	739	H DC BAD	426	H DC NOK	482	H DC BAD	739	H DC BAD			482	H DC BAD
39	H DC NOK	529	H DC NOK	115	H DC BAD	0	H DC NOK	515	H DC NOK	564	H DC BAD	328 pixels	H DC OK			564	H DC BAD
52	H DC NOK	623	H DC NOK	273	H DC BAD	3	H DC NOK	529	H DC NOK	568	H DC BAD					568	H DC BAD
84	H DC NOK	638	H DC NOK	336	H DC BAD	28	H DC NOK	638	H DC NOK	581	H DC BAD					581	H DC BAD
104	H DC NOK	702	H DC NOK	348	H DC BAD	39	H DC NOK	702	H DC NOK	669	H DC BAD					669	H DC BAD
120	H DC NOK	735	H DC NOK	370	H DC BAD	52	H DC NOK	735	H DC NOK	673	H DC BAD					673	H DC BAD
187	H DC NOK	777	H DC NOK	423	H DC BAD	104	H DC NOK	777	H DC NOK	698	H DC BAD					698	H DC BAD
214	H DC NOK	778	H DC NOK	438	H DC BAD	120	H DC NOK	778	H DC NOK	721	H DC BAD					721	H DC BAD
224	H DC NOK	826	H DC NOK	470	H DC BAD	187	H DC NOK	841	H DC NOK	798	H DC BAD					798	H DC BAD
290	H DC NOK	840	H DC NOK	482	H DC BAD	290	H DC NOK	932	H DC NOK	808	H DC BAD					808	H DC BAD
298	H DC NOK	841	H DC NOK	518	H DC BAD	298	H DC NOK	1020	H DC NOK	881	H DC BAD					881	H DC BAD
345	H DC NOK	932	H DC NOK	532	H DC BAD	345	H DC NOK	519 pixels	H DC OK	902	H DC BAD					902	H DC BAD
424	H DC NOK	1020	H DC NOK	564	H DC BAD	424	H DC NOK			943	H DC BAD					943	H DC BAD
425	H DC NOK	522 pixels	H DC OK	568	H DC BAD	425	H DC NOK			568	H DC BAD					1000 pixels	H DC OK
488	H DC NOK			698	H DC BAD	518	H DC NOK			502pixels	H DC NOK						
518	H DC NOK			710	H DC BAD	575	H DC NOK			498pixels	H DC OK						
575	H DC NOK			721	H DC BAD	678	H DC NOK										
678	H DC NOK			736	H DC BAD	788	H DC NOK										
739	H DC NOK			753	H DC BAD	871	H DC NOK										
788	H DC NOK			761	H DC BAD	877	H DC NOK										
871	H DC NOK			779	H DC BAD	899	H DC NOK										
877	H DC NOK			798	H DC BAD	900	H DC NOK										
899	H DC NOK			809	H DC BAD	956	H DC NOK										
956	H DC NOK			882	H DC BAD	327 pixels	H DC OK										
329 pixels	H DC OK			925	H DC BAD												
				966	H DC BAD												
				469pixels	H DC NOK												
				499pixels	H DC OK												

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

SEPT-OCT-DEC						OCT-DEC-JAN						DEC-JAN-FEB					
SWIR1		SWIR2		SWIR3		SWIR1		SWIR2		SWIR3		SWIR1		SWIR2		SWIR3	
211	H DC NOK	121	H DC NOK	237	H DC NOK	161	H DC NOK	121	H DC NOK	30	H DC NOK	246	H DC NOK	87	H DC NOK	389	H DC NOK
251	H DC NOK	166	H DC NOK	1011	H DC NOK	211	H DC NOK	166	H DC NOK	99	H DC NOK	781	H DC NOK	208	H DC NOK	396	H DC NOK
306	H DC NOK	295	H DC NOK	30	H DC NOK	251	H DC NOK	295	H DC NOK	131	H DC NOK	784	H DC NOK	550	H DC NOK	698	H DC NOK
419	H DC NOK	544	H DC NOK	99	H DC NOK	306	H DC NOK	550	H DC NOK	141	H DC NOK	334 pixels	H DC OK	625	H DC NOK	936	H DC NOK
444	H DC NOK	582	H DC NOK	131	H DC NOK	419	H DC NOK	582	H DC NOK	237	H DC NOK			677	H DC NOK	969	H DC NOK
448	H DC NOK	687	H DC NOK	141	H DC NOK	444	H DC NOK	687	H DC NOK	266	H DC NOK			894	H DC NOK	221 pixels	H DC OK
545	H DC NOK	831	H DC NOK	205	H DC NOK	448	H DC NOK	831	H DC NOK	337	H DC NOK			422 pixels	H DC OK		
547	H DC NOK	900	H DC NOK	266	H DC NOK	545	H DC NOK	900	H DC NOK	364	H DC NOK						
556	H DC NOK	969	H DC NOK	278	H DC NOK	547	H DC NOK	969	H DC NOK	389	H DC NOK						
819	H DC NOK	430 pixels	H DC OK	337	H DC NOK	556	H DC NOK	429 pixels	H DC OK	448	H DC NOK						
1021	H DC NOK			364	H DC NOK	784	H DC NOK			504	H DC NOK						
346 pixels	H DC OK			448	H DC NOK	819	H DC NOK			529	H DC NOK						
				504	H DC NOK	1021	H DC NOK			550	H DC NOK						
				529	H DC NOK	343pixels	H DC OK			565	H DC NOK						
				550	H DC NOK					579	H DC NOK						
				565	H DC NOK					640	H DC NOK						
				579	H DC NOK					669	H DC NOK						
				640	H DC NOK					674	H DC NOK						
				669	H DC NOK					712	H DC NOK						
				674	H DC NOK					763	H DC NOK						
				712	H DC NOK					794	H DC NOK						
				763	H DC NOK					804	H DC NOK						
				794	H DC NOK					836	H DC NOK						
				804	H DC NOK					868	H DC NOK						
				836	H DC NOK					890	H DC NOK						
				868	H DC NOK					917	H DC NOK						
				890	H DC NOK					924	H DC NOK						
				917	H DC NOK					936	H DC NOK						
				924	H DC NOK					956	H DC NOK						
				936	H DC NOK					957	H DC NOK						
				956	H DC NOK					994	H DC NOK						
				957	H DC NOK					1011	H DC NOK						
				994	H DC NOK					203pixels	H DC OK						
				201pixels	H DC OK												

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

SEPT-OCT-DEC							OCT-DEC-JAN						DEC-JAN-FEB					
496	H DC BAD	438	H DC BAD	211	H DC NOK		144	H DC NOK	14	H DC NOK	211	H DC NOK	830	H DC NOK	1012	H DC BAD	85	H DC NOK
977	H DC BAD	14	H DC NOK	300	H DC NOK		496	H DC NOK	122	H DC NOK	300	H DC NOK	989	H DC NOK	295	H DC NOK	533pixels	H DC OK
88	H DC NOK	122	H DC NOK	486	H DC NOK		666	H DC NOK	167	H DC NOK	486	H DC NOK	583pixels	H DC OK	473	H DC NOK		
144	H DC NOK	167	H DC NOK	538	H DC NOK		801	H DC NOK	438	H DC NOK	538	H DC NOK			838	H DC NOK		
666	H DC NOK	232	H DC NOK	757	H DC NOK		826	H DC NOK	473	H DC NOK	757	H DC NOK			951	H DC NOK		
801	H DC NOK	551	H DC NOK	980	H DC NOK		830	H DC NOK	551	H DC NOK	980	H DC NOK			653pixels	H DC OK		
826	H DC NOK	580	H DC NOK	560pixels	H DC OK		873	H DC NOK	580	H DC NOK	550pixels	H DC OK						
873	H DC NOK	940	H DC NOK				945	H DC NOK	940	H DC NOK								
945	H DC NOK	694pixels	H DC OK				957	H DC NOK	1012	H DC NOK								
957	H DC NOK						977	H DC NOK	686pixels	H DC OK								
590pixels	H DC OK						989	H DC NOK										
							590pixels	H DC OK										

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

1.4. Bad pixels

There are 5 new bad pixels identified in this reporting period.

Reporting period mid-Dec 2020 - Mid-Mar 2021																														
CAMERA	STRIP	pixel numbers (ID L1 A)																												
		NEW BAD	BAD (from previous periods)																											
left	swir1	**877**	3	28	39	84	104	298	345	352	644	956																		
left	swir2		711	717	841	863																								
left	swir3	**325, 737**	4	82	90	172	250	370	419	438	568	759	761	890																
center	swir1		448	819	1021																									
center	swir2	**121**	57	114	295	769	831	900																						
center	swir3	**631**	29	30	99	131	141	413	448	476	529	550	565	579	640	669	674	712	763	794	804	836	889	890	917	938	994			
right	swir1		364	496																										
right	swir2		14	438	470																									
right	swir3		496																											

Table 6: Overview Bad pixels

1.5. 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 Update of SWIR absolute following linear degradation model**
PROBAV_X_R_000_20161201_01.xml	Update dark currents Update of SWIR absolute following linear degradation model**
PROBAV_X_R_000_20161201_01.xml	Update dark currents Update of SWIR absolute following linear degradation model**
PROBAV_X_R_000_20161201_01.xml	Update dark currents Update of SWIR absolute following linear degradation model**
PROBAV_X_R_000_20161201_01.xml	Update dark currents Update of SWIR absolute following linear degradation model**
PROBAV_X_R_000_20170101_01.xml	Update dark currents 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 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 Update of SWIR absolute following linear degradation model**
PROBAV_X_R_000_20170401_01.xml	Update dark currents Update of SWIR absolute following linear degradation model** SWIR status map updated : 1 bad pixel added
PROBAV_X_R_000_2017051_01.xml	Update dark currents Update of SWIR absolute following linear degradation model** Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model***
PROBAV_X_R_000_20170601_01.xml	Update dark currents Update of SWIR absolute following linear degradation model** Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model***
PROBAV_X_R_000_20170701_01.xml	Update dark currents Update of SWIR absolute following linear degradation model** Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model*** SWIR status map updated : 1 bad pixel added
PROBAV_X_R_000_20170801_01.xml	Update dark currents Update of SWIR absolute following linear degradation model** Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model*** SWIR status map updated : 2 bad pixel added
PROBAV_X_R_000_20170901_01.xml	Update dark currents Update of SWIR absolute following linear degradation model***, new coef applied for RIGHT SWIR strips***** Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** SWIR status map updated : 2 bad pixel added

PROBAV_X_R_000_20171001_01.xml	Update dark currents Update of SWIR absolute following linear degradation model***, new coef applied for RIGHT SWIR strips***** 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 Update of SWIR absolute following linear degradation model***, new coef applied for RIGHT SWIR strips***** 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 Update of SWIR absolute following linear degradation model***, new coef applied for RIGHT SWIR strips***** 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 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 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 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 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 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 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 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 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 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. 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. 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. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** ****
PROBAV_X_R_000_20190101_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** ****
PROBAV_X_R_000_2010201_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** ****

PROBAV_X_R_000_20190301_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** ****
PROBAV_X_R_000_20190401_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** ****
PROBAV_X_R_000_20190501_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** One new bad pixel added : left SWIR3 PixelID 82 (0-based)
PROBAV_X_R_000_20190601_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** Two new bad pixel added : left SWIR2 PixelID 717 (0-based) and CENTER SWIR1 PixelID 448
PROBAV_X_R_000_20190701_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** Update equalization coefficients LEFT and RIGHT SWIR strips based on Yaw maneuver analyses.
PROBAV_X_R_000_20190801_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** ****
PROBAV_X_R_000_20190901_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** ****

PROBAV_X_R_000_20191001_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** ****
PROBAV_X_R_000_20191101_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** ****
PROBAV_X_R_000_20191201_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** Two new bad pixel added : CENTER SWIR3 Pixel ID 529 (0-based)) and RIGHT SWIR1 Pixel ID 364(0-based)).
PROBAV_X_R_000_20200101_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** ****
PROBAV_X_R_000_20200204_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** ****
PROBAV_X_R_000_20200222_01.xml	One new bad pixel added : CENTER SWIR3 Pixel ID CENTER SWIR3 Pixel ID 836 (0-based))

PROBAV_X_R_000_20200301_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** ****
PROBAV_X_R_000_20200318_01.xml	Three new bad pixel added : CENTER SWIR3 Pixel ID 413 (0-based), Pixel ID 550 (0-based), Pixel ID 565 (0-based)
PROBAV_X_R_000_20200402_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** ****
PROBAV_X_R_000_20200502_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** Three new bad pixel added : Center SWIR3 Pixel ID 669 and Pixel ID 674 (0-based), LEFT SWIR3 PixelD 4 (0-based).
PROBAV_X_R_000_20200601_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** ****
PROBAV_X_R_000_20200704_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** Three bad pixels Center SWIR3 Pixel ID 141 (0-based), LEFT SWIR1 PixelD 84 (0-based), LEFT SWIR3 PixelD 890 (0-based),
PROBAV_X_R_000_20200801_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** One bad pixel: Center SWIR3 Pixel ID 712 (0-based).

PROBAV_X_R_000_20200901_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** One bad pixel: Left SWIR2 Pixel ID 841 (0-based).
PROBAV_X_R_000_20201001_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** ****
PROBAV_X_R_000_20201101_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** ****
PROBAV_X_R_000_20201201_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** One bad pixel: : pixel ID496 in the Right SWIR3 (0-based).
PROBAV_X_R_000_202101XX_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** One bad pixel: pixel ID496 in the Right SWIR1 (0-based).
PROBAV_X_R_000_20210201_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** ****
PROBAV_X_R_000_202103XX_01.xml	Update dark currents. Update of LEFT BLUE and CENTER BLUE absolute calibration coefficients following linear degradation model **with new coef** **** 3 new bad pixels: • LEFT SWIR3 strip Pixel ID 325 • LEFT SWIR3 strip Pixel ID 737 • CENTER SWIR3 strip Pixel ID 631

Table 7: Radiometric ICP-file updates Collection 1

2. Geometric Image Quality

2.1. Summary

The quarterly Average Location Error (ALE) over the period 16/12/2020 – 15/03/2021 was 70 m (1б = 86 m) for all spectral bands (combined cameras). Compared to the previous reporting period, the ALE has increased (deteriorated) by 5 m (7.1%). The total number of Ground Control Points used decreased by 28% compared to previous quarter and was 4,351,509 in total. The daily Average Location Error compliance (ALE < 300 m) was 99.05%, which is 0.17% lower than in the previous quarter.

For the combined cameras, the inter-band geometric accuracy range was 21 – 56 m (standard deviation range 5 – 13 m), which is 0.06 – 0.17 of a pixel (333 m). The average inter-band RED-NIR registration accuracy was 22 m, which is the same as in previous reporting period.

The multi-temporal geometric accuracy was 86.75% (-1.23% compared to previous quarter) for the VNIR and 94.67% (-0.59% compared to previous quarter) for the combined VNIR/SWIR. The multi-temporal accuracies over the last full year are 88.15% and 95.69% for VNIR and VNIR/SWIR, respectively.

The geometric ICP file generated on 8/9/2016, valid from 1/9/2016 has remained valid throughout the reporting period. However, for further improvement of the geometric accuracy, a new geometric ICP file was generated on 5/03/2021 with validity date of 01/01/2021. The new reprocessing campaign (C2) also will take this improvement into account.

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	**16/12/2020 - 15/01/2021**	**16/01/2021 - 15/02/2021**	**16/02/2021 - 15/03/2021**
BLUE	66.45, σ = 36.79	80.55, σ = 39.05	56.07, σ = 29.03
RED	69.33, σ = 39.71	84.80, σ = 42.98	53.38, σ = 28.70
NIR	69.30, σ = 39.44	83.64, σ = 42.04	58.75, σ = 30.76
SWIR1	103.86, σ = 62.74	123.74, σ = 67.42	78.68, σ = 48.36
SWIR2	65.51, σ = 37.46	77.65, σ = 39.09	53.46, σ = 29.01
SWIR3	60.95, σ = 34.26	68.40, σ = 34.69	55.99, σ = 29.26

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

CAMERA 2 Mean and standard deviation ALE [m]			
Strip\Period	**16/12/2020 - 15/01/2021**	**16/01/2021 - 15/02/2021**	**16/02/2021 - 15/03/2021**
BLUE	79.08, σ = 38.93	93.54, σ = 41.12	46.01, σ = 26.84
RED	80.95, σ = 40.04	94.88, σ = 41.59	45.91, σ = 26.89
NIR	79.09, σ = 39.18	92.34, σ = 40.82	47.69, σ = 27.95
SWIR1	76.09, σ = 41.21	89.37, σ = 42.00	52.32, σ = 29.66
SWIR2	72.56, σ = 40.39	84.43, σ = 42.18	53.94, σ = 31.31
SWIR3	72.35, σ = 39.48	82.34, σ = 41.79	57.43, σ = 33.51

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

CAMERA 3 Mean and standard deviation ALE [m]			
Strip\Period	**16/12/2020 - 15/01/2021**	**16/01/2021 - 15/02/2021**	**16/02/2021 - 15/03/2021**
BLUE	67.40, σ = 39.12	59.02, σ = 33.76	71.34, σ = 41.09
RED	80.37, σ = 47.20	73.26, σ = 42.00	86.75, σ = 49.82
NIR	74.20, σ = 43.67	68.81, σ = 39.13	79.98, σ = 46.10
SWIR1	58.20, σ = 34.60	57.23, σ = 33.24	61.43, σ = 35.67
SWIR2	81.14, σ = 45.11	76.38, σ = 41.93	87.33, σ = 47.49
SWIR3	119.10, σ = 68.68	108.29, σ = 62.68	130.26, σ = 73.92

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

In the reporting period, the average L1C location error data was 75.0 m, which is 2.9 m (4.1%) 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 16/12/2020 – 15/01/2021
- from 16/01/2021 – 15/02/2021
- from 16/02/2021 – 15/03/2021

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
16/12/2020	98.88	99.53	99.48	99.66	10590	68.75	91.35	12532	59.66	77.93	12358	58.93	68.48	11124	63.16	77.63
17/12/2020	98.79	99.27	99.41	99.63	11491	71.34	106.94	13138	62.75	87.79	12610	61.33	72.62	12032	64.06	87.93
18/12/2020	98.5	98.93	98.9	99.5	11048	71.26	101.84	11920	63.82	82.19	11253	64.68	87.26	10613	62.97	91.37
19/12/2020	98.4	99.11	99.24	99.63	12094	77.26	107.24	13306	69.61	94.48	13032	68.65	74.31	10301	69.29	89.7
20/12/2020	99.01	99.49	99.35	99.8	12683	68.95	82.9	14124	64.38	76.36	13941	67.27	82.85	11729	69.1	80.12
21/12/2020	98.72	99.48	99.42	99.68	10150	73.04	100.5	11602	66.42	83.52	11461	68.97	92.48	10432	68.41	88.29
22/12/2020	98.12	98.6	98.69	99.67	10774	74.02	101.62	12332	68.57	87.2	11715	69.87	87.7	11345	65.89	85.67
23/12/2020	98.54	99.14	99.04	99.55	11983	72.32	98.47	13705	65.55	80.38	12967	65.73	82.14	11860	67.03	81.25
24/12/2020	98.69	99.31	99.41	99.82	10924	74.01	94.84	12550	67.37	77.62	12649	63.46	62.1	10232	68.96	68.66
25/12/2020	98.75	99.33	99.44	99.69	9279	76.86	85.12	10831	69.22	81.9	10690	66.09	78.2	9456	72.7	80.71
26/12/2020	98.8	99.32	99.38	99.51	9710	76.82	96.21	11351	68.71	88.78	10831	66.39	86.16	10666	71.37	93.73
27/12/2020	98.58	98.97	99.05	99.63	11441	81.99	100.69	12868	73.31	79.51	12004	73.91	93.11	11343	73.7	79.65
28/12/2020	98.36	99.18	99.1	99.63	11855	82.71	95.66	12678	72.31	72.72	12709	70.59	78.53	10017	75.3	84.64
29/12/2020	99.05	99.28	99.46	99.73	12074	70.95	77.74	13586	64.08	73.58	13624	62.25	82.11	10941	67.36	79.87
30/12/2020	98.89	99.18	99.23	99.81	10734	84.2	92.3	12320	77.35	98.9	12412	73	93.38	11157	75.45	68.34
31/12/2020	98.29	99.26	99.11	99.58	9231	89.01	97.24	10598	77.76	94.4	10573	74.72	86.35	9200	77.59	83.11
01/01/2021	98.75	99.22	99.22	99.57	12241	72.61	91.41	13256	65.76	76.58	13135	64.84	83.62	10597	67.82	92.83
02/01/2021	98.76	99.09	99.1	99.54	13299	68.79	92.69	14633	63.87	78.82	14401	64.07	76.17	11306	67.05	90.18
03/01/2021	98.84	99.33	99.33	99.66	10974	80.04	103.16	12445	70.11	75.82	12466	67.21	81.23	10699	71.73	80
04/01/2021	98.63	99.33	99.39	99.6	10881	75.49	106.36	12149	64.79	83.75	12096	61.61	77.68	11240	67.12	87.43
05/01/2021	98.53	99.14	99.04	99.43	9598	87.21	87.66	10889	77.69	91.14	10526	74.39	83.92	9858	82.97	101.86
06/01/2021	98.51	98.8	98.73	99.46	12020	73.76	94.81	12994	68.41	84.25	12708	69.32	88.85	10543	71.51	92.27
07/01/2021	98.99	99.25	99.28	99.72	12255	67.34	86.24	13460	63.28	84.52	13518	64.01	68.62	11122	67.18	85.64
08/01/2021	98.75	99.14	99.27	99.62	11169	74.26	90.51	12733	71.92	91.02	12453	74.23	75.3	11521	73.25	98.49
09/01/2021	98.74	99.15	99.03	99.51	12168	72.47	95.43	13039	69.08	92.07	12676	71.91	86.14	11608	70.27	95.66
10/01/2021	98.87	99.32	99.31	99.64	13051	69.98	87.13	14329	62.41	73.53	14275	61.99	77.27	11856	65.47	83.25
11/01/2021	98.64	99.14	99.26	99.59	13522	79.66	80.53	15192	70.82	76.18	15208	67.58	74.65	11540	74.55	86.48
12/01/2021	99.07	99.36	99.49	99.65	10368	74.45	74.95	12402	67.53	76.65	12194	63.58	67.75	10117	69.61	82.26
13/01/2021	98.97	99.49	99.48	99.68	9162	71.21	84.14	10884	61.35	77.46	10739	59.33	66.34	10170	64.07	88.37
14/01/2021	98.86	99.37	99.31	99.67	12497	75.1	100.79	13941	66.44	84.45	13429	65.37	84.59	12097	66.58	81.2
15/01/2021	98.95	99.34	99.29	99.58	13418	69.83	92.53	14621	62.9	82.37	14400	62.82	82.03	11150	66.13	96.04
Averages	**98.12**	**98.6**	**98.69**	**99.43**	**352684**	**75.02**	**93.52**	**396408**	**67.65**	**82.77**	**389053**	**66.71**	**80.06**	**337872**	**69.6**	**85.89**

Table 11: Daily achieved compliance and the daily average location error (in m) for all spectral bands in the period 16/12/2020 – 15/01/2021.

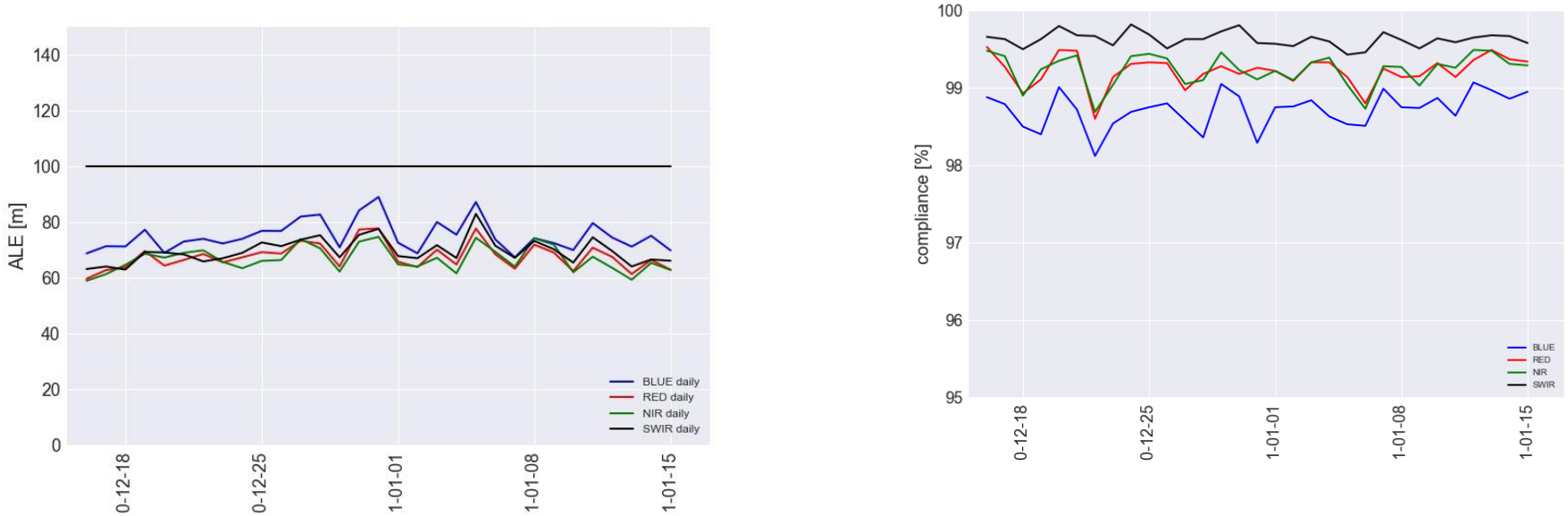


Figure 18: Daily average location error in the period from 16/12/2020 – 15/01/2021 (left) and the average daily compliance of the spectral bands (right).

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
16/01/2021	99.06	99.46	99.49	99.73	11734	67.86	92.8	13222	60.7	65.1	13268	61.48	77.22	10406	65.62	86.24
17/01/2021	99	99.34	99.48	99.72	10578	67.31	98.01	12350	63.1	81.45	12190	61.68	77.01	10900	65.87	82.05
18/01/2021	98.98	99.2	99.19	99.69	12004	71.04	115.3	13662	64.05	81.68	13391	63.13	76.42	12582	65.51	89.39
19/01/2021	98.45	99.18	99.08	99.46	18187	75.68	92.74	18793	69.6	83.01	18010	67.69	78.86	11019	78.92	98.45
20/01/2021	98.62	99.37	99.46	99.7	15871	76.74	88.42	18205	66.89	74	14368	65.02	72.36	8131	70.55	77.16
21/01/2021	99.22	99.52	99.64	99.72	11804	66.31	78.82	13071	62.55	85.29	13033	61.23	63.79	11294	66.62	83.76
22/01/2021	98.59	99	99.23	99.62	14999	76.66	101.02	16604	75.78	94.34	13418	72.9	82.05	11055	72.04	91.19
23/01/2021	98.43	98.46	98.27	99.63	21760	79.56	89.98	21005	77.38	102.48	16254	79.61	86.51	11249	72.27	89.62
24/01/2021	98.62	98.94	99.04	99.59	19051	77.96	103.06	18148	72.29	87	12877	75.65	88.91	8999	74.76	100.25
25/01/2021	99.12	99.31	99.41	99.7	13818	68.43	88.11	13739	60.94	70.91	13823	60.71	69.7	11199	64.54	71.87
26/01/2021	99.13	99.48	99.49	99.66	18411	68.42	91.11	20186	62.21	85.02	18667	59.22	70	11614	63.72	86.27
27/01/2021	98.87	99.31	99.15	99.27	7436	70.77	100.53	8293	63.97	93.76	4950	66.7	95.74	409	85.93	68.31
28/01/2021	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData
29/01/2021	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData
30/01/2021	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData
31/01/2021	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData
01/02/2021	98.75	99.14	98.8	99.52	21112	70.68	95.8	21513	65.31	77.15	19988	68.97	100.69	20125	69.61	96.48
02/02/2021	98.75	99.1	99.08	99.54	21026	71.11	105.99	16618	65.07	81.82	16440	64.25	77.66	13867	69.85	84.23
03/02/2021	99.01	99.4	99.44	99.66	24608	73.89	78.64	27722	66.43	68.49	20665	65	77.33	11852	71.91	84.43
04/02/2021	99.08	99.23	99.51	99.69	11680	72.63	99.22	13377	68.71	113.98	13435	65.47	89.62	11540	68.77	80.87
05/02/2021	99.04	99.52	99.36	99.62	19222	69.39	101.1	20272	61.49	92.11	11171	63.62	84.01	10123	65.69	86.1
06/02/2021	98.78	99.01	98.89	99.61	13145	75.02	94.45	12314	69.08	77.12	11847	73.42	92.64	10391	70.43	99.07
07/02/2021	98.78	98.86	99.09	99.72	16610	78.63	89	13193	72.58	99.17	12581	72.71	82.43	9837	72.11	85.31
08/02/2021	99.14	99.5	99.53	99.77	11186	71.53	88.91	12973	64.63	82.92	12893	63.64	78.93	10774	66.38	80.92
09/02/2021	99.02	99.34	99.44	99.7	10133	76.96	97.07	11845	68.31	67.42	12182	66.11	67.68	10875	68.54	75.87
10/02/2021	98.82	99.24	99.24	99.67	12158	81.72	93.49	13256	73.45	77.92	13021	71.2	78.61	11649	72.56	82.8
11/02/2021	98.75	98.96	98.78	99.64	15261	74.13	98.11	15988	69.27	81.94	15950	73.43	103.43	12919	69.83	83.48
12/02/2021	98.9	99.18	99.18	99.68	15802	70.66	87.79	17709	65.83	77.31	17518	67.52	68.8	13693	68.68	89.65
13/02/2021	99.35	99.44	99.43	99.63	6172	63.8	88.11	7139	58.87	91.22	6497	61.64	79.48	6253	63.72	86.33
14/02/2021	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData
15/02/2021	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData
Averages	**98.89**	**99.22**	**99.23**	**99.64**	**373768**	**72.68**	**94.3**	**391197**	**66.74**	**83.7**	**348437**	**66.88**	**80.8**	**272755**	**69.78**	**85.6**

Table 12: Daily achieved compliance and the daily average location error (in m) for all spectral bands in the period 16/01/2021 – 15/02/2021.

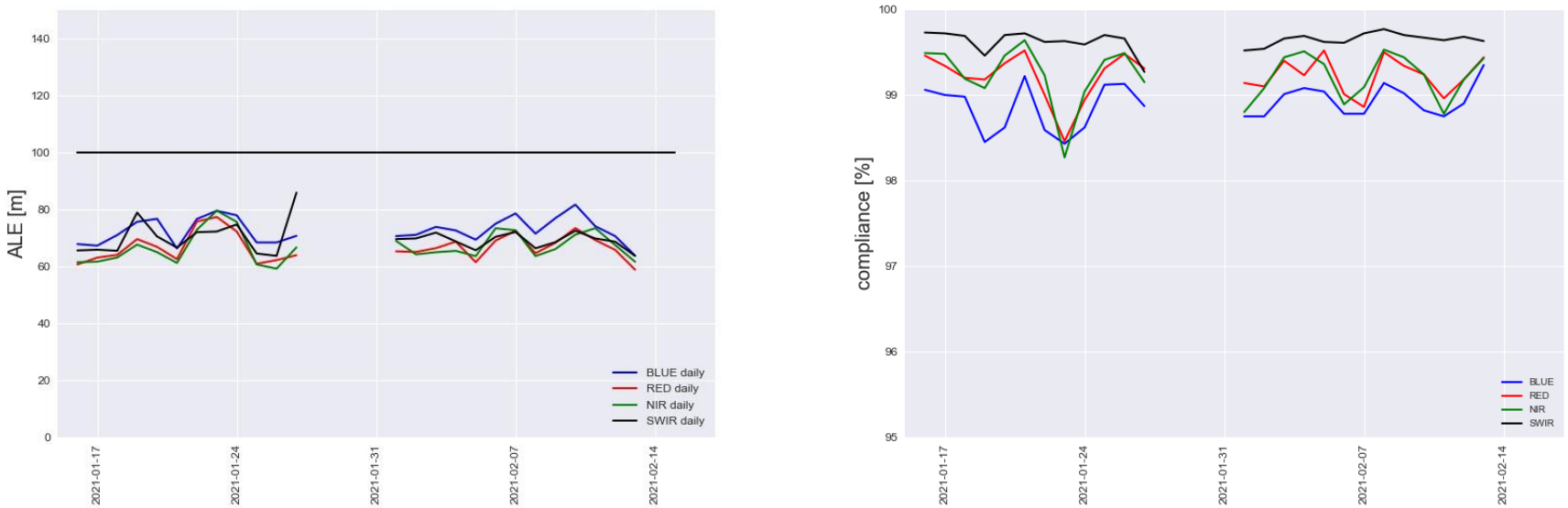


Figure 19: Daily average location error in the period from 16/01/2021 – 15/02/2021 (left) and the average daily compliance of all spectral bands (right).

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
16/02/2021	98.48	98.9	98.94	99.66	12503	77.79	93.63	13498	72.52	75.9	13437	75.29	80.09	11221	72.14	80.78
17/02/2021	99.28	99.46	99.44	99.82	9445	65.83	74.52	10674	63.49	64.76	10920	64.61	78.25	8781	64.6	85.96
18/02/2021	99.03	99.39	99.34	99.71	7537	71.14	83.47	9083	67.55	84.11	8800	68.1	75.04	8297	66.03	83.57
19/02/2021	98.94	99.33	99.16	99.61	9968	72.15	88.15	11281	66.42	78.05	10994	68.16	88.81	10234	66.98	90.85
20/02/2021	98.56	99.32	99.27	99.63	14434	80.45	86.58	15986	71.34	82.89	15807	70.86	81.12	9485	71.9	84.06
21/02/2021	99.04	99.27	99.31	99.7	11755	72.54	91.77	13251	68.17	75.21	13251	69.8	61.73	11064	70.57	78.84
22/02/2021	99.05	99.41	99.51	99.7	12262	69.24	93.61	13643	63.89	78.26	13941	63	71.8	12524	66.36	78.57
23/02/2021	98.91	99.17	99.31	99.73	12456	74.64	89.49	13680	69.4	86.29	13894	67.29	81.46	12399	68.99	69.09
24/02/2021	98.71	99.14	99.14	99.58	13390	75.08	93.4	14999	67.66	81.37	14838	67.82	91.58	13000	71.86	94.92
25/02/2021	98.85	99.06	99.07	99.63	13092	74.66	94.01	14390	70.85	98.32	14508	70.09	74.91	11551	70.18	83.62
26/02/2021	99.15	99.43	99.56	99.72	14218	67.88	78.81	15786	63.06	68.92	15956	63.25	70.93	13724	65.55	74.93
27/02/2021	98.68	99.24	99.11	99.74	12309	76.15	94.72	13624	72	89.58	13740	73.85	92.13	12935	68.82	77
28/02/2021	98.03	98.42	98.46	99.68	9094	88.91	120	7013	81.05	88.11	6997	83.85	85.34	6560	77.22	93.67
01/03/2021	98.59	99.05	99.15	99.64	20782	77.04	94.75	22335	68.67	80.59	16685	70.72	81.64	13174	66.83	88.19
01/03/2021	98.59	99.05	99.15	99.64	20782	77.04	94.75	22335	68.67	80.59	16685	70.72	81.64	13174	66.83	88.19
02/03/2021	98.58	99.19	99.32	99.73	15376	73.1	83.21	17313	65.84	86.33	16994	64.7	76.28	14164	66.63	79.98
03/03/2021	98.66	99.21	99.25	99.65	12346	87.75	94.24	13848	78.72	69.89	13967	77.24	78.18	12433	81.74	84.05
04/03/2021	98.8	99.09	99.07	99.63	12165	93.97	90.71	13700	88.11	86.82	13856	84.77	87.74	13016	85.49	86.86
05/03/2021	98.29	98.93	99	99.61	15281	89.12	104.03	16237	80.22	77.61	16058	78.13	93.01	14602	77.58	84.67
06/03/2021	98.78	99.15	99.1	99.69	16078	76.48	88.44	17261	70.73	78.29	16803	71.6	90.2	14065	74.27	89.24
07/03/2021	98.93	99.25	99.27	99.73	13189	72.7	79.51	14873	68.88	75.23	14752	68.15	77.64	13114	71.58	84.86
08/03/2021	98.84	99.35	99.27	99.69	12306	74.38	99.66	13938	68.32	84.02	13608	69.37	95.21	12378	72.3	87.26
09/03/2021	98.67	99.13	99.15	99.7	14636	71.4	96.48	16016	64.89	84.34	15737	65.4	87.18	14228	66.99	74
10/03/2021	98.76	99.15	99.22	99.58	15016	71.21	98.64	16736	63.63	82.85	15960	63.7	90.66	13905	67.69	93
11/03/2021	98.9	99.21	99.28	99.73	14582	64.18	65.01	16644	59.48	80.16	15951	57.85	75.23	13426	62.48	76.69
12/03/2021	98.8	99.4	99.45	99.77	9148	68.23	84.8	11200	60.1	86.04	10784	57.49	73.67	10443	61.86	72.11
13/03/2021	98.77	99.3	99.32	99.68	9502	65.75	97.61	11538	58.53	85.9	11246	58.13	82.64	11056	61.73	86.72
14/03/2021	97.89	99	98.93	99.35	10153	75.89	120.05	11847	65.14	95.91	11428	66.34	100.99	10251	67.78	115.95
15/03/2021	98.68	99.03	99.06	99.59	13219	68.34	96.33	14859	62.14	93.22	14778	61.04	87.02	11725	64.66	88.08
Averages	**98.73**	**99.17**	**99.19**	**99.67**	**377024**	**74.93**	**92.08**	**417588**	**68.6**	**82.05**	**402375**	**68.67**	**82.49**	**346929**	**69.57**	**84.68**

Table 13: Daily achieved compliance and the daily average location error (in m) for all spectral bands in the period 16/02/2021 – 15/03/2021.

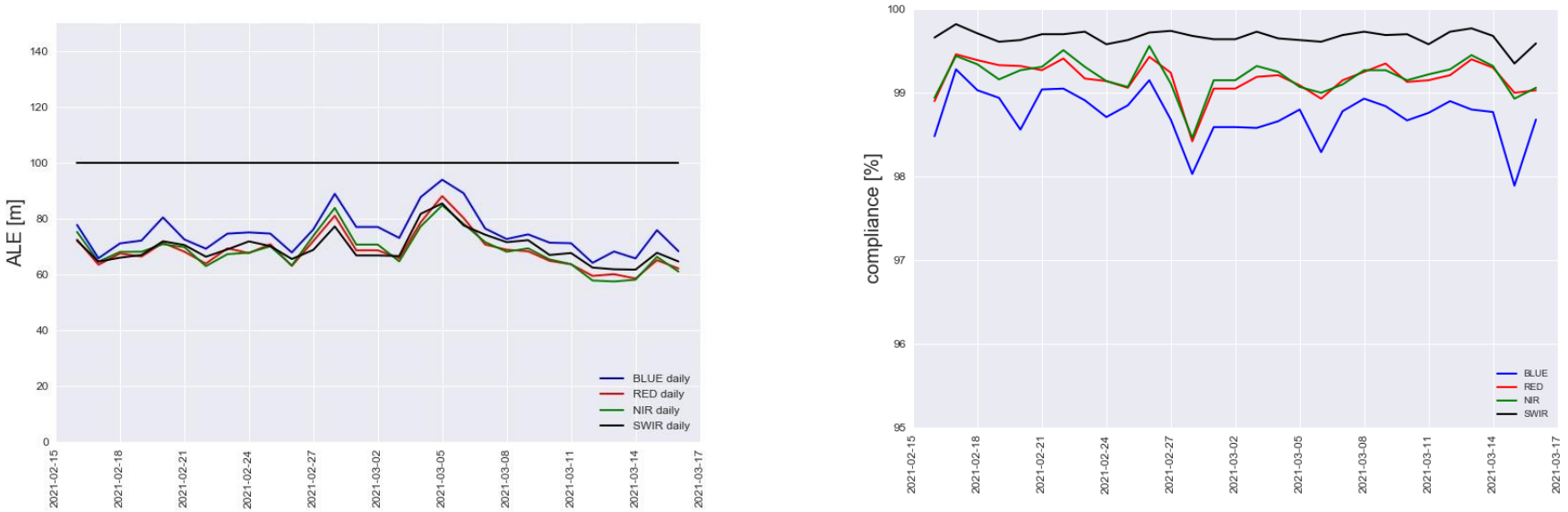


Figure 20: Daily average location error in the period from 16/02/2021 – 15/03/2021 (left) and the average daily compliance of all spectral bands (right).

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	37.80, σ = 6.95
BLUE-NIR	46.94, σ = 8.37
BLUE-SWIR	54.06, σ = 8.46
RED-NIR	21.48, σ = 5.44
RED-SWIR	41.99, σ = 5.74
NIR-SWIR	43.25, σ = 5.53

Table 14: Inter-band geolocation accuracy and standard deviation for period 16/12/2020 – 15/01/2021 for the combined cameras, at 95% confidence level.

Band pair	Inter-band error [m]
BLUE-RED	37.47, σ = 6.56
BLUE-NIR	46.42, σ = 8.57
BLUE-SWIR	54.99, σ = 8.20
RED-NIR	21.89, σ = 4.93
RED-SWIR	43.74, σ = 5.14
NIR-SWIR	45.13, σ = 6.11

Table 15: Inter-band geolocation accuracy and standard deviation for period 16/01/2021 – 15/02/2021 for the combined cameras, at 95% confidence level.

Band pair	Inter-band error [m]
BLUE-RED	38.31, σ = 7.18
BLUE-NIR	48.72, σ = 12.79
BLUE-SWIR	56.15, σ = 8.52
RED-NIR	21.81, σ = 4.67
RED-SWIR	45.34, σ = 6.26
NIR-SWIR	46.01, σ = 6.14

Table 16: Inter-band geolocation accuracy and standard deviation for period 16/02/2020 – 15/03/2021 for the combined cameras, at 95% confidence level.

For the combined cameras, the inter-band geometric accuracy range was 21 – 56 m (standard deviation range 5 – 13 m), which is 0.06 – 0.17 of a pixel (333 m). The average inter-band RED-NIR registration accuracy was 22 m, which is the same as in previous reporting period.

2.3.3. Multi-temporal geometric accuracy

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

- 85.56% for the VNIR sensor (59,960 GCPs used),
- 94.44% for the VNIR/SWIR combined (64,625 GCPs used).

The compliance values are 2.43% and 0.82% lower than in the previous quarter for VNIR and VNIR/SWIR, respectively.
The multi-temporal accuracies over the last full year for VNIR and VNIR/SWIR are 87.50% and 95.38%, respectively.

The spatial maps indicating the multitemporal geometric compliance (green=compliant, red=not compliant) are presented in Figure 21 and Figure 22 for VNIR and VNIR/SWIR, respectively.

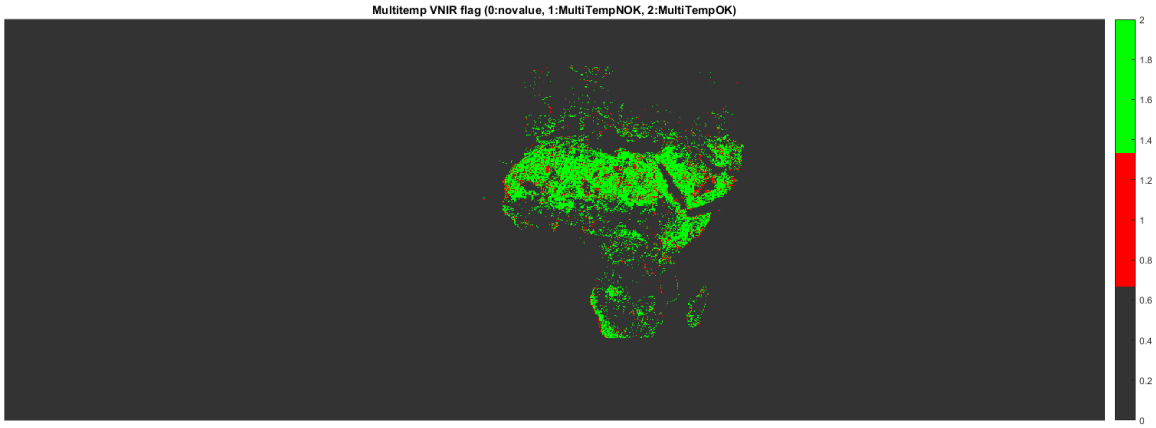


Figure 21: Multi-temporal geometric accuracy for the VNIR sensor for 16/12/2020 – 15/03/2021. Compliant areas are marked in green; areas with accuracy below 95% are marked in red. Grey areas represent no data.

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.

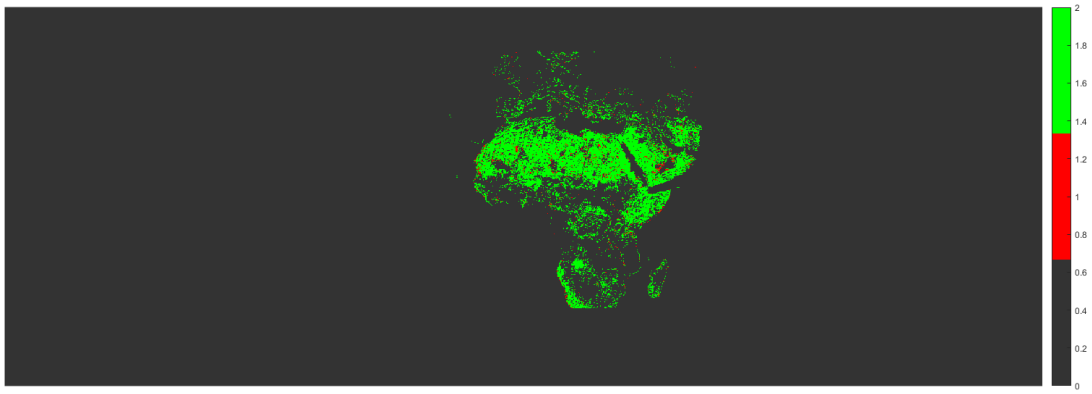


Figure 22: Multi-temporal geometric accuracy for the VNIR/SWIR combined sensors for 16/12/2020 – 15/03/2021. Compliant areas are marked in green; areas with accuracy below 95% are marked in red. Grey areas represent no data.

2.4. Geometric ICP file

On 05.03.2021 new ICP files with validity date set to 01.01.2021 were created.

ICP filename	Description
PROBAV_ICP_GEOMETRIC#LEFT_20210101_V01 PROBAV_ICP_GEOMETRIC#CENTER_20210101_V01 PROBAV_ICP_GEOMETRIC#RIGHT_20210101_V01	Although still within the requirements, an increasing ALE trend necessitated generating new ICP files.

4. 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