QUARTERLY IMAGE QUALITY REPORT

IQR#003

Reporting period from 16/06/2014 to 15/09/2014

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1.0	19/09/2014	All	Initial version	

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1. Radiometric Image Quality

1.1. Summary

Absolute, interband and multi-temporal accuracies remain within the requirements (ie. 5% and 3 %).

To improve the inter-band and inter-camera consistency and to correct for a small decrease in the LEFT BLUE and NIR response, an update of the LEFT BLUE, LEFT NIR and CENTER RED absolute calibration coefficients is proposed:

- LEFT BLUE and NIR radiances will be increased with respectively 1.07 % and 1.3 % with the next ICP update.
- The CENTER RED radiance will be decreased with about 2.1% with the next ICP update.

It should be noted that the PROBA-V CENTER camera response is stable based on the moon and Libya-4 results. Adaptation of the CENTER RED absolute calibration coefficient is proposed to correct for a bias in the coefficient, and not to correct for a decay of the CENTER camera.

A monthly update of the dark current and the SWIR equalisation coefficients have been performed in Q3 to correct for high frequency inter-pixel variation. The BAD pixel status has been given to three more SWIR pixels. The total number of SWIR bad pixels is currently 20.

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 Figure 1, Figure 2 and Figure 3 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 Figure 2, Figure 4 and Figure 6 with a 3 % error bar (as expected uncertainty for an individual result). Results are obtained with the absolute calibration parameters obtained, through vicarious calibration, at the end of the commissioning phase as reported in table 11 of the Radiometric commissioning [RD-4], except for the BLUE center and BLUE right results. For these latter strips an update of the absolute calibration coefficients was performed (BLUE center radiances decreased with 1.8%; and BLUE right radiances increased wit 1.2 %) on 26 June 2014 in order to improve the interband and intercamera consistency. Data acquired since 26 June are therefore processed with the updated absolute calibration coefficients.

For all bands and cameras the average results remain **well within the 5 % accuracy requirements**.

For a discussion of the monthly variations we refer to section 1.2.3 .

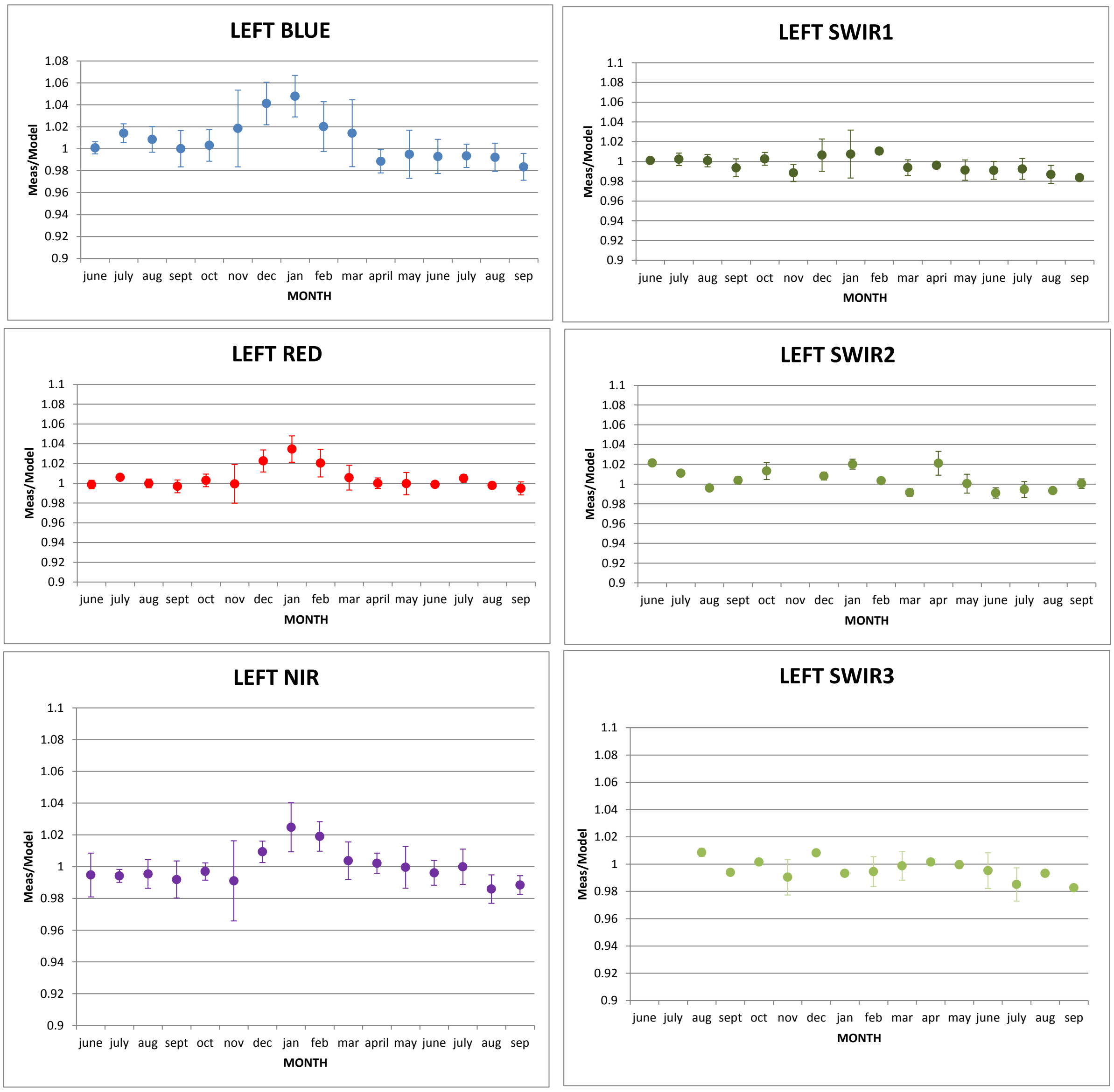


Figure 1. Libya-4 desert calibration results: LEFT camera

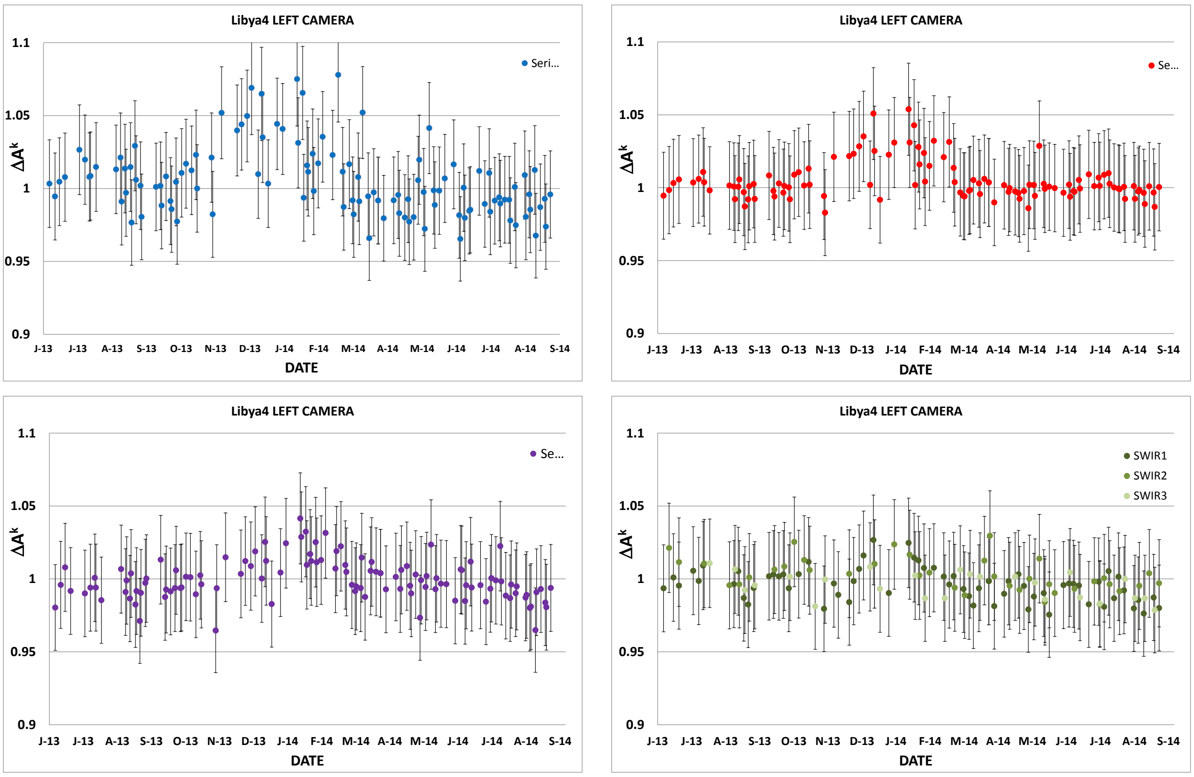


Figure 2. Libya-4 desert calibration results: LEFT camera – individual results

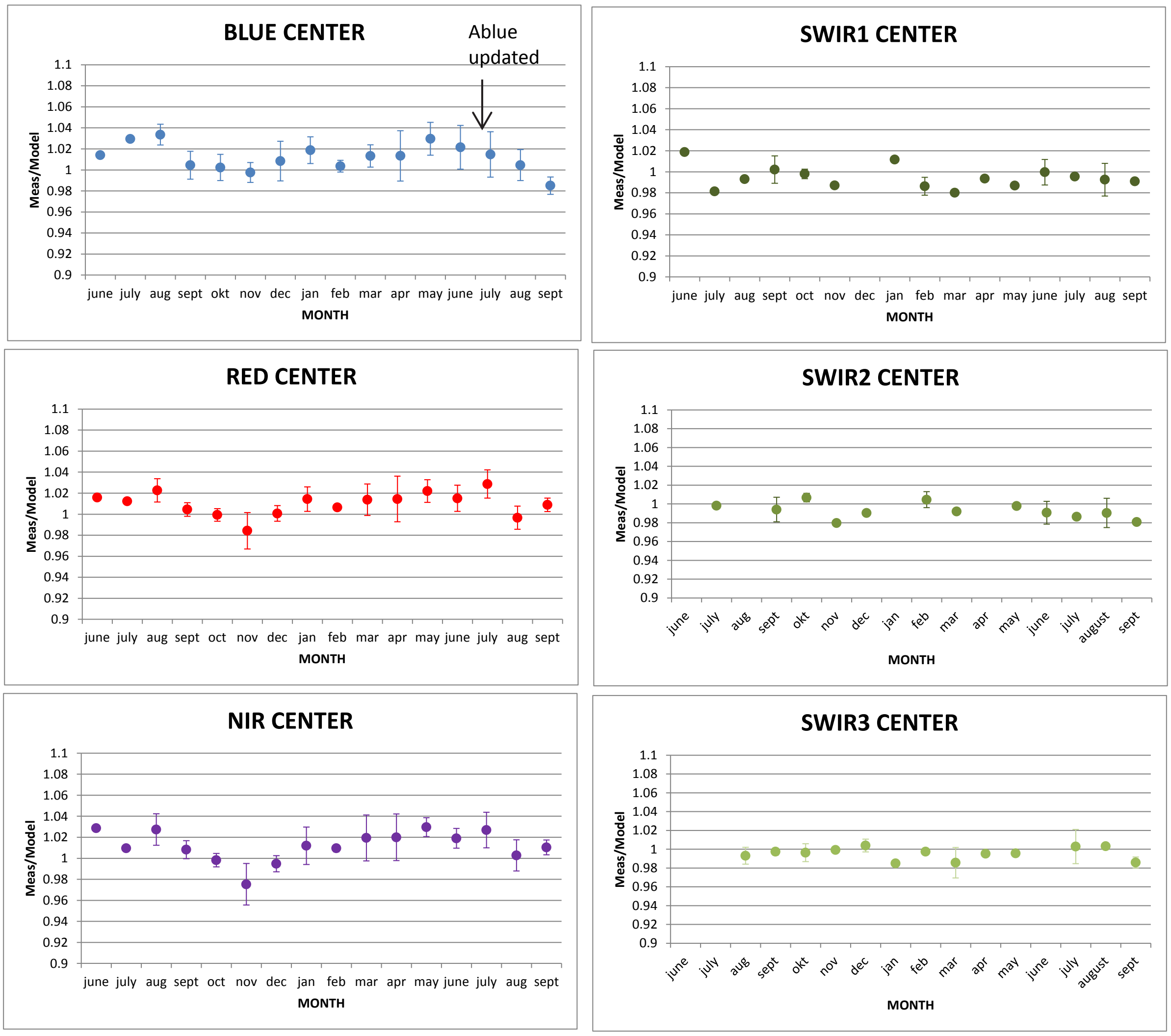


Figure 3. Libya-4 desert calibration results: CENTER camera-monthly averaged results

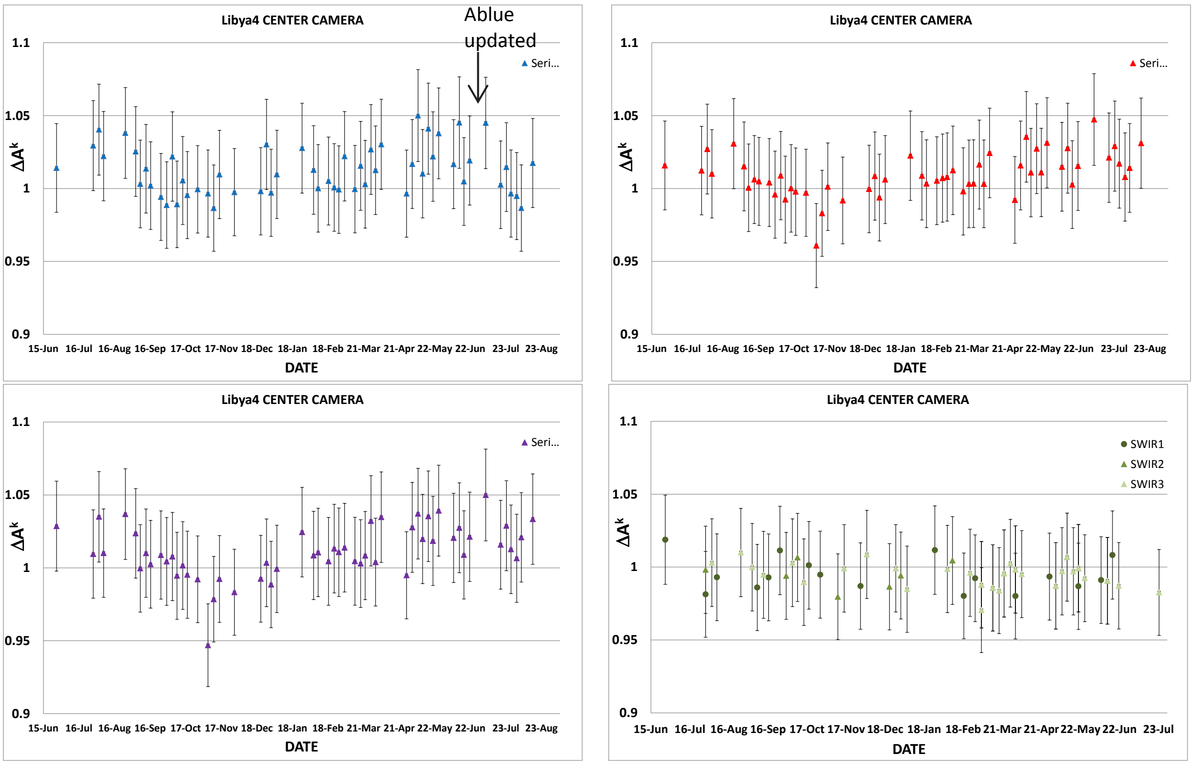


Figure 4. Libya-4 desert calibration results: CENTER camera-individual results

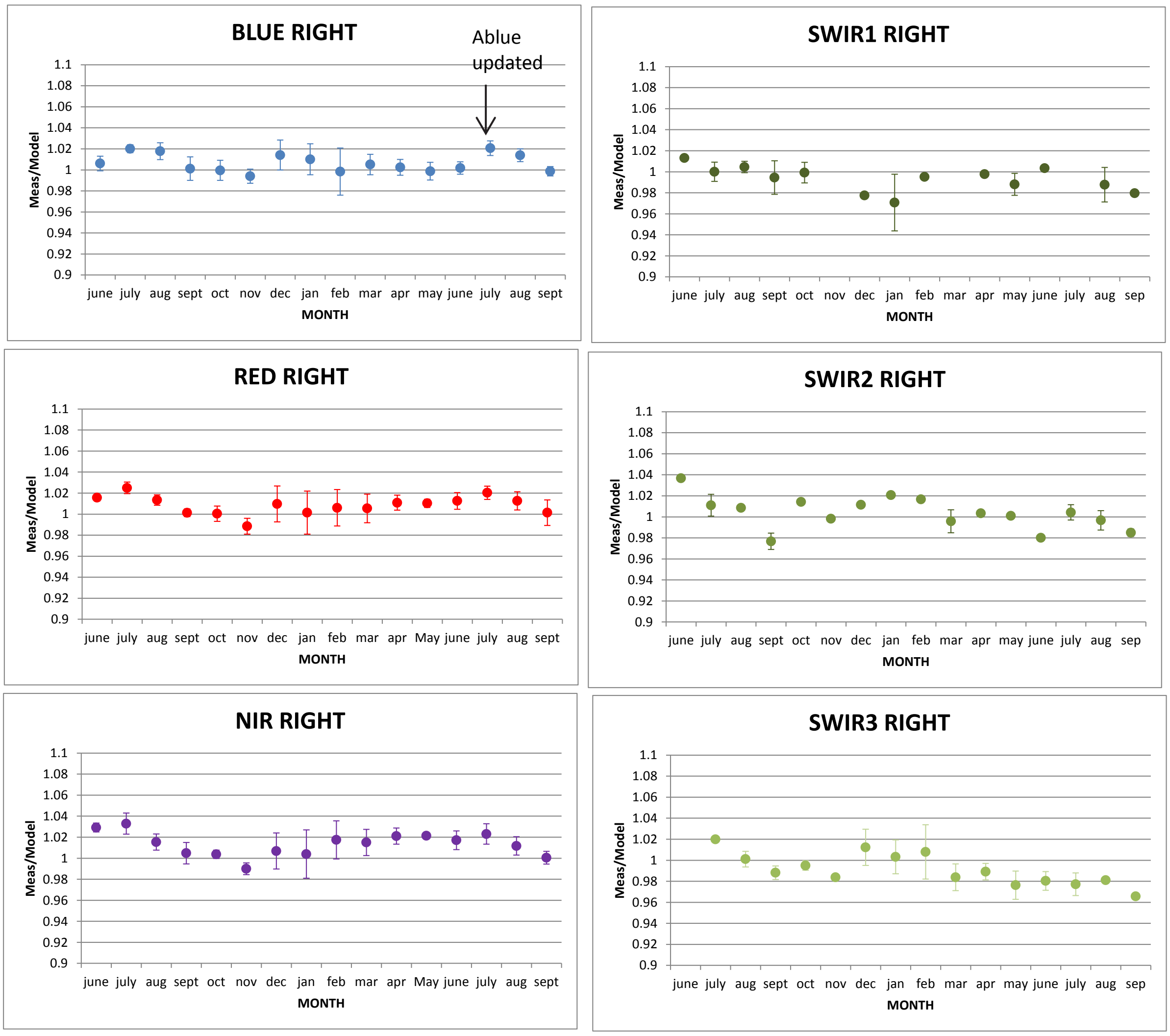


Figure 5. Libya-4 desert calibration results: RIGHT camera-monthly averaged results

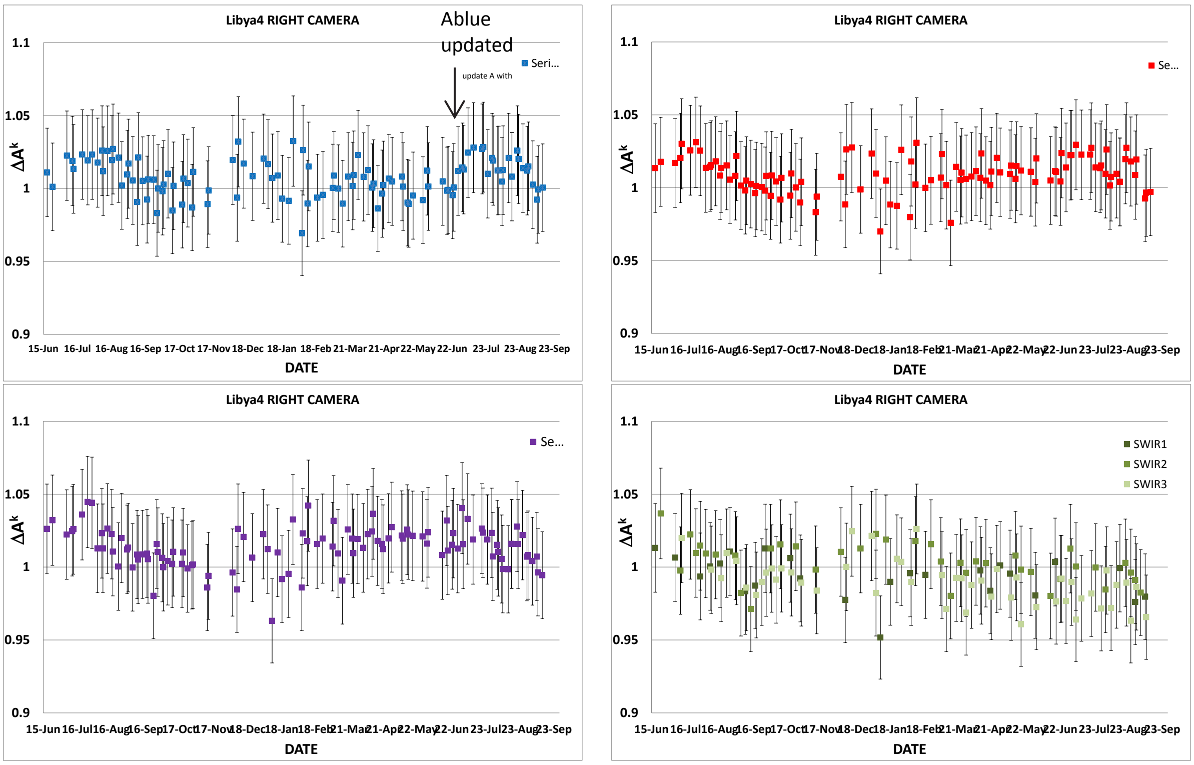


Figure 6. Libya-4 desert calibration results: CENTER camera- individual results

1.2.1.2. Rayleigh calibration

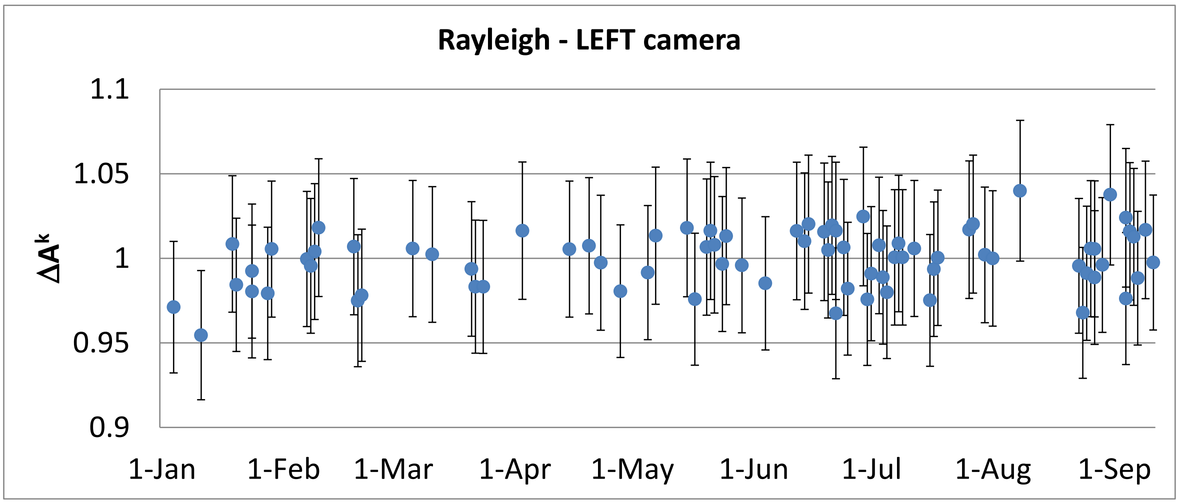
Methodology

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. The PROBA-V data were processed with the absolute calibration parameters obtained, through vicarious calibration, at the end of the commissioning phase except for the BLUE center and BLUE right results. For these latter strips an update of the absolute calibration coefficients was performed (BLUE center radiances decreased with 1.8%; and BLUE right radiances increased wit 1.2 %) on 26 June 2014 in order to improve the interband and intercamera consistency. Data acquired since 26 June are therefore processed with the updated absolute calibration coefficients.

Through more frequent acquisition over the South of Indian and South-East Pacific Ocean Rayleigh calibration sites, the number of valid scenes for the CENTER camera was significantly increased compared to previous reporting period.
All Rayleigh calibration results remain well **within the 5 % absolute accuracy requirement.**



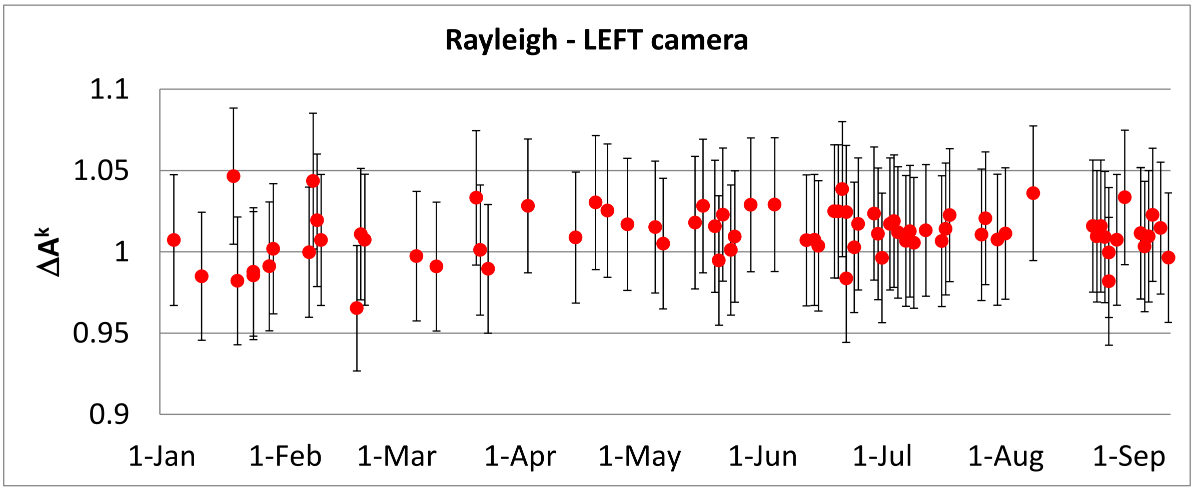
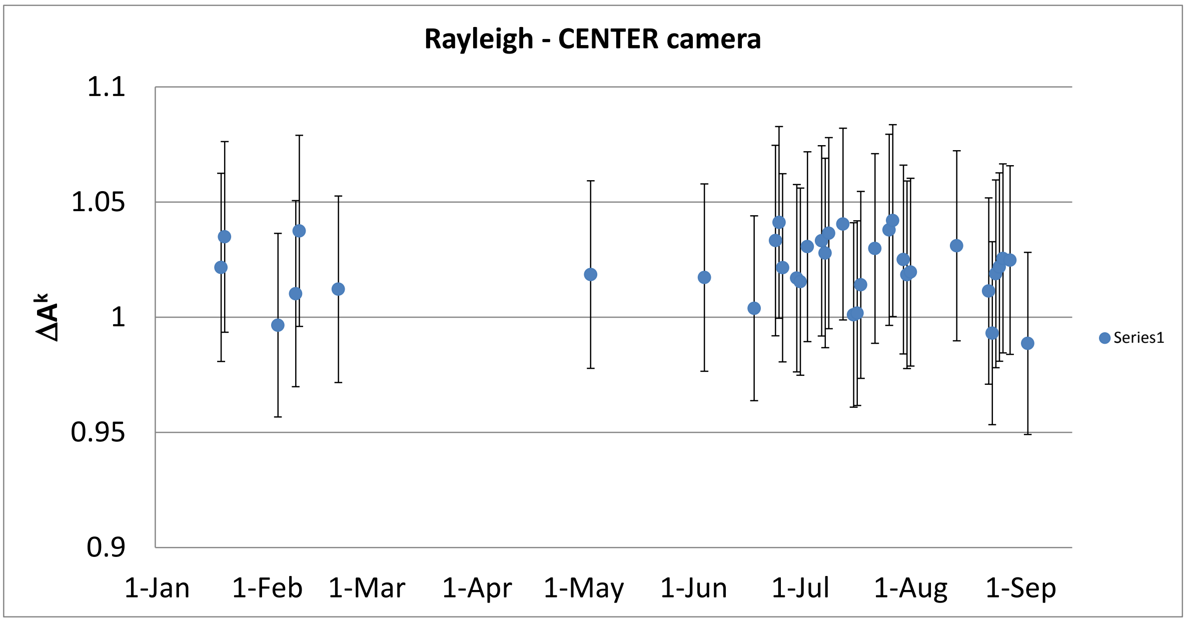


Figure 7. Rayleigh absolute calibration results: LEFT camera



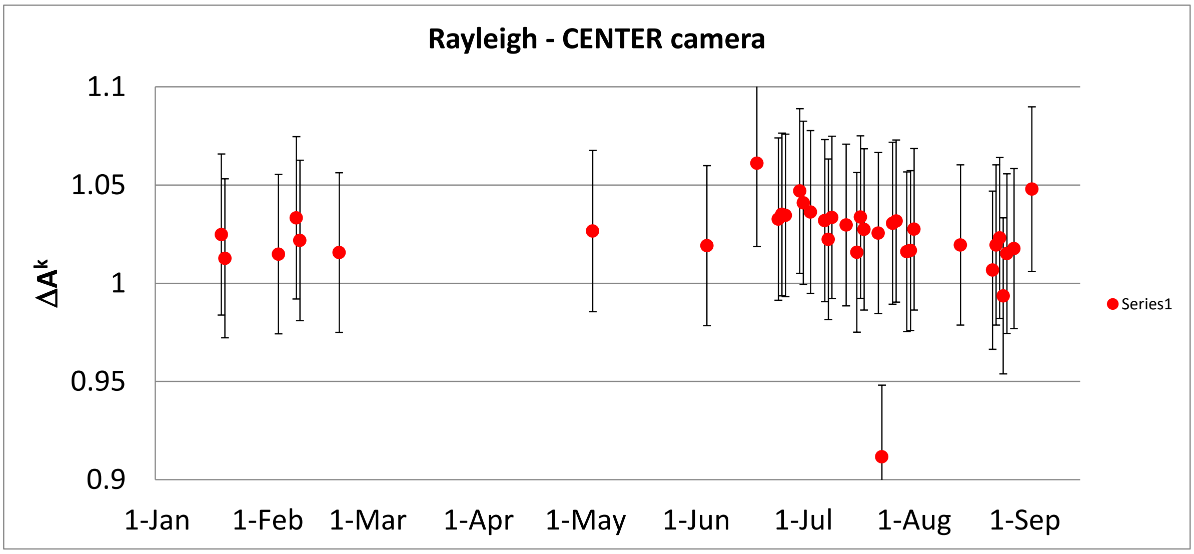
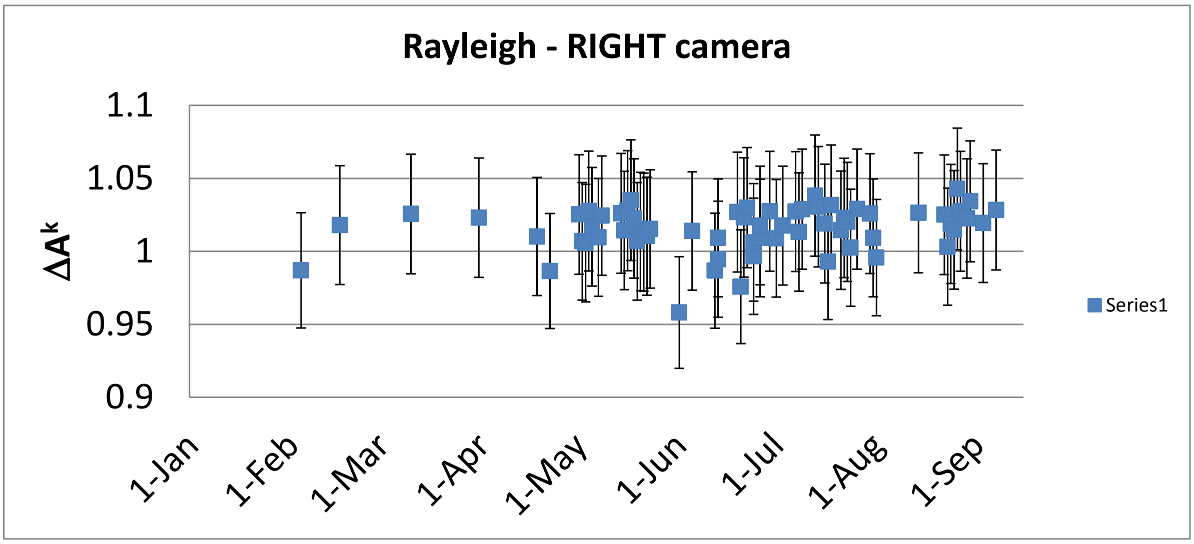


Figure 8. Rayleigh absolute calibration results: CENTER camera



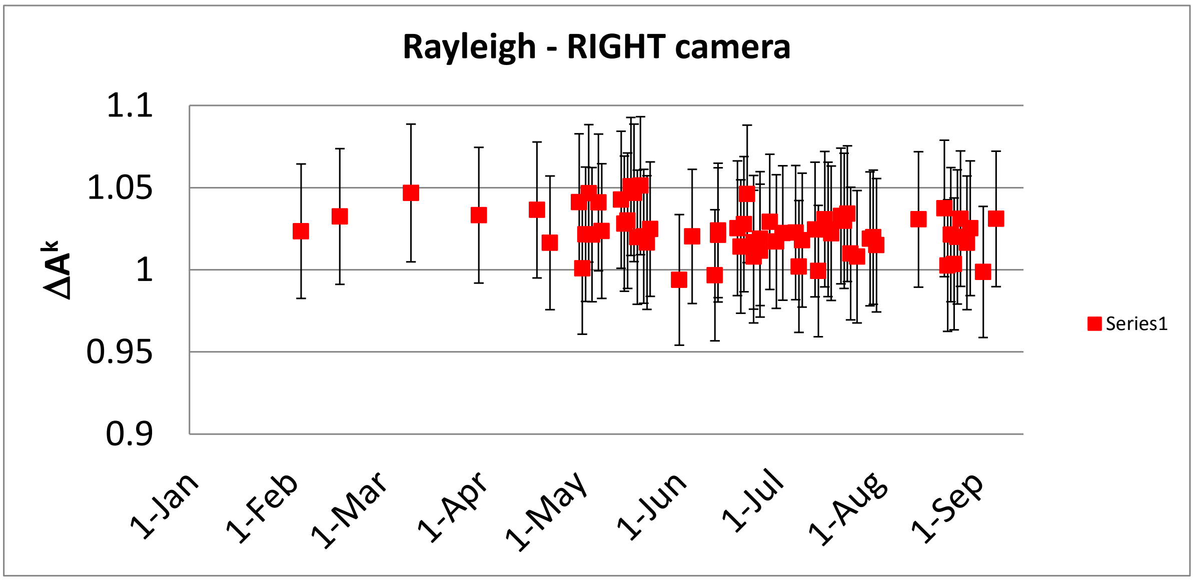


Figure 9. Rayleigh absolute calibration results: RIGHT camera

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 November 2013 to September 2014) is given in Figure 10 for all cameras.

The overall inter-band calibration accuracy is well **within 3 %** for all cameras and bands.

For the LEFT BLUE the DCC calibration results show a slight decrease in the PROBA-V response compared to the start of the operational phase. A similar decrease is observed in the Libya-4 desert calibration results of the LEFT camera (Figure 2, Figure 3). Furthermore the inter-camera consistency analysis showed that for the overlapping pixels the LEFT BLUE radiances are lower than the CENTER BLUE radiances (see section 1.2.4). This motivates an update of the LEFT BLUE absolute calibration coefficients.

The LEFT NIR interband DCC calibration result shows also a slight decrease, comparable to Libya-4 results. Therefore the NIR LEFT absolute calibration coefficient will be updated.

A similar decrease in the CENTER and RIGHT NIR interband DCC calibration coefficients compared to start of the operational phase is observed; however Libya-4 and/or moon calibration results give not yet a clear evidence of a possible decay.

The observed larger NIR-RED interband inconsistency has been further analysed., through among others intercamera analysis (see section 1.2.4). Based on these analyses it has been concluded that the RED CENTER strip gives slightly too high radiances. Based on the NIR-RED DCC results of the last two months (ie August and September) an absolute calibration parameter change of 2.1 % is proposed for the CENTER RED ICP file.

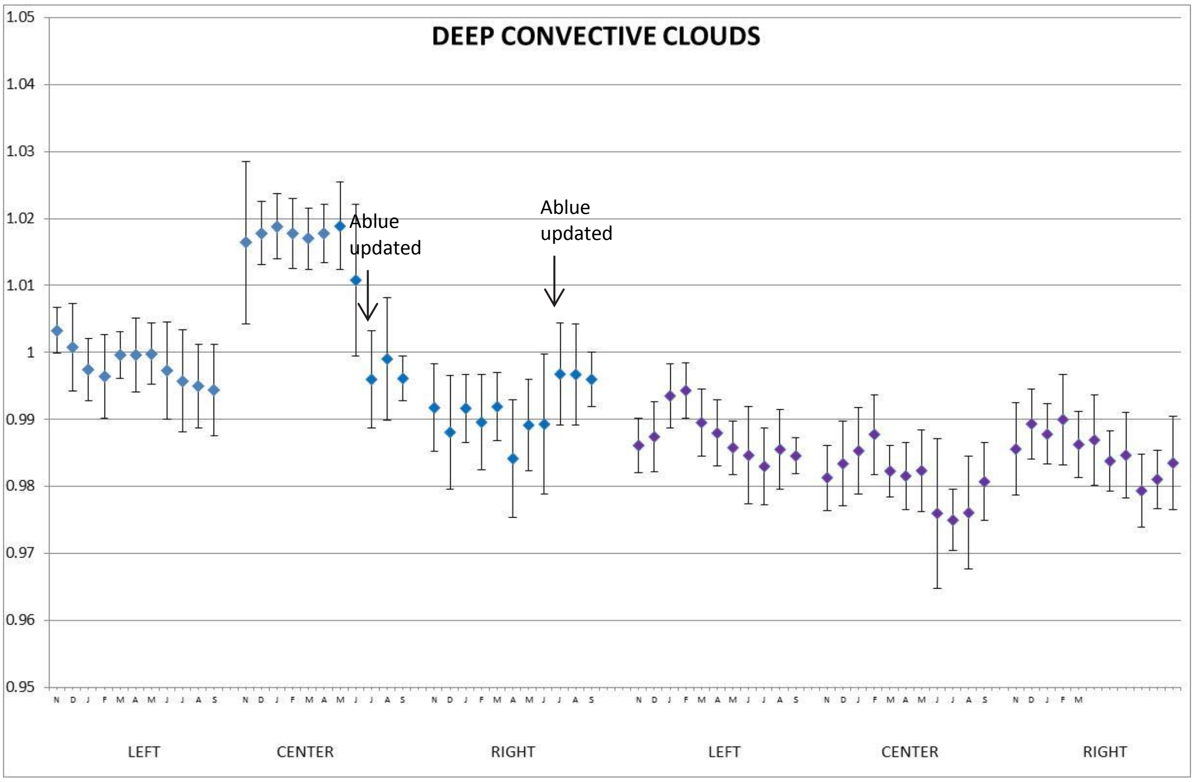


Figure 10. DCC inter-band calibration results: LEFT, CENTER and RIGHT camera

1.2.3. Multi-temporal radiometric accuracy

The multi-temporal radiometric calibration requirement for PROBA-V specifies a 3 % multi-temporal accuracy. This requirement is currently assessed through vicarious calibration over the stable Libya-4 desert and monthly observations of the moon for the CENTER camera. The lunar calibration has been recently implemented. The aim is to finally verify VITO's lunar calibration implementation against the Eumetsat's GSICS lunar calibration implementation within the coming lunar calibration workshop scheduled for end 2014 (https://gsics.nesdis.noaa.gov/wiki/Development/20140624). Therefore the presented lunar calibration results are to be considered as preliminary results.

Results

The Libya-4 results have been given in Figure 1 to Figure 6. The Lunar calibration results for the VNIR CENTER camera bands, normalised to July 2013, are given in Figure 11.

Please note that the decrease in the moon BLUE band multi-temporal calibration results observed for July/Aug/Sept is due to the update of the BLUE center camera absolute calibration coefficient in order to improve interband and inter-camera consistency.
The seasonal trend (eg. decrease during the winter months) observed in the lunar calibration results might be due to libration effects of the moon (personal discussion with T Stone).
The lunar calibration results of summer 2014 compared to those of summer 2013 are very well in line (within 1%, neglecting the blue calibration coefficient update). Therefore based on the moon results there is no evidence of a decay of the CENTER camera. This is also confirmed by the Libya-4 desert results.

For the LEFT and RIGHT camera multi-temporal analysis is only based on Libya-4 observations. Here we see a slight decrease in the LEFT BLUE and NIR response. As some evidence of decay is also seen in the DCC results, a slight adjustment to the absolute calibration coefficients will be done. Based on the Libya-4 desert results of the last two months (ie Aug, Sept): LEFT BLUE and NIR radiances will be increased with respectively 1.07 % and 1.3 %

For the RIGHT camera the Libya-4 desert results of summer 2014 are very similar to those of summer 2013.

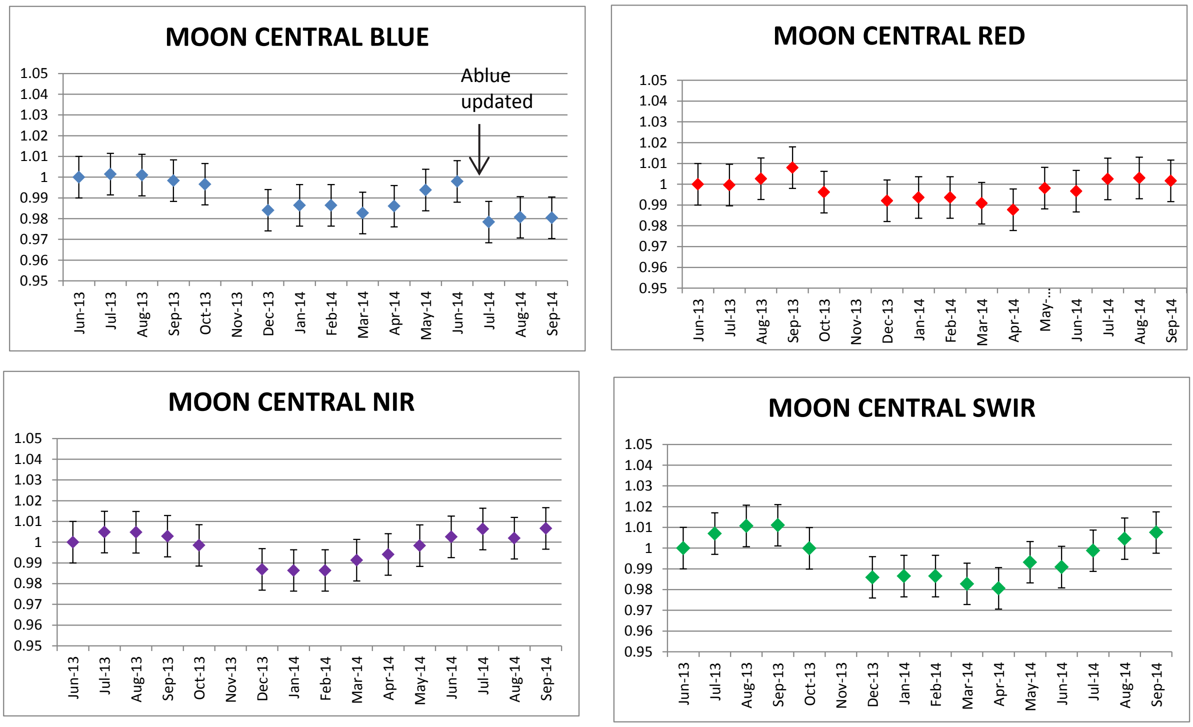


Figure 11. Lunar Calibration results CENTER camera normalised to July

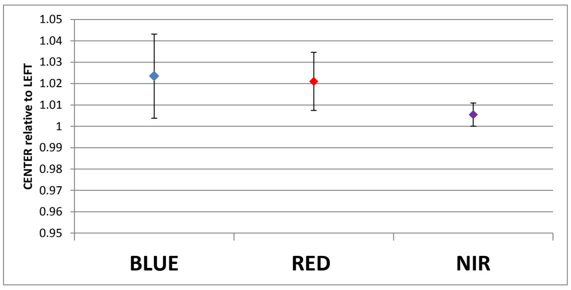
1.2.4. Inter-camera consistency analysis

Methodology

The Camera-to-camera method exploits the L1B overlap region products of two adjacent cameras. First, the DNs in the L1B overlap products are converted to TOA reflectance. Next, the data are projected and an ASCII file containing the TOA radiance values for the pairs of overlapping pixels is generated. A linear regression through the origin is performed for the pairs of overlapping observations and the slope of the regression is calculated. This slope gives an indication of the radiometric difference of respectively the CENTER camera compared to the RIGHT Camera and CENTER camera to LEFT Camera.

Results

In Figure 12 the results of the intercamera analysis applied to overlap images of August/Sept 2014 are given. Inter-camera differences are within 3 %. The smallest differences are observed for the NIR strips of all cameras, also the BLUE center and right strips seem to be very consistent. The BLUE center –left difference will be decreased with the proposed LEFT BLUE absolute calibration update as discussed in the previous section. Furthermore the RED CENTER radiances will be reduced by about 2.1 % with the foreseen ICP file update which will result in an improved inter-camera consistency



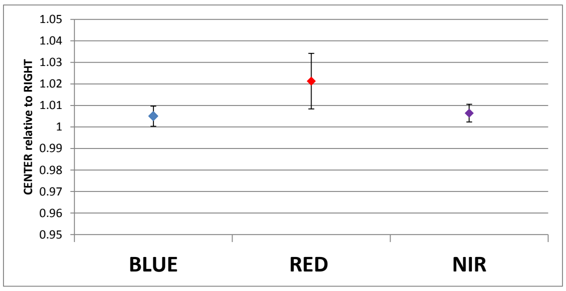


Figure 12. Inter-camera consistency analysis

1.3. Dark current

Method

An analysis of the dark current is done monthly. Monthly averaged results are compared to the previous two months according to the following protocol:

- Monthly difference plots :
  - All dark current results obtained during a period of one month for observations performed with a long integration time (> 1s) 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 SWIR strips an IT of **0.02s** is used, for VNIR strips **0.006s**.
  - 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 (Figure 13): 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.
- Dark current outlier analysis :
  - The 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 status 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"**

Besides these monthly plots and outlier detection, the dark current evolution is monitored per pixel. This is done through linear regression of the dark current per pixel against date of acquisition. Based on this slope the expected change over a 1 year period is calculated per pixel and per strip in average.

Results

Monthly difference plots for VNIR dark currents are given in Figure 13, Figure 14, Figure 15 for respectively LEFT, CENTER and RIGHT camera, for the SWIR dark currents in Figure 16, Figure 17 and Figure 18.

Results are similar as reported in the previous quarterly report. Dark current differences for the VNIR bands are well below 1 DN. For SWIR bands several pixels show differences larger than 4 DN. For those pixels a detailed outlier analysis is performed as given in Table 1, Table 2 and Table 3.

Four pixels, all from LEFT SWIR 3 strip, with status 'H DC BAD' have been observed in the last 3 months. As these pixels do not yet show a deviating behaviour under light conditions (see section) their final status is still considered good.

In Figure 19, Figure 20 and Figure 21 plots of the change of the dark current values are given, expressed in percentage difference over a period of 1 year with taking into account the dark current observations from October 2013 till 15 September 2014. Only very minor differences in the expected evolution are observed compared to previous quarterly reporting. The LEFT SWIR 3 camera shows the largest increase in dark current values since October, but the calculated increase is lower than estimated during the previous reporting periods.

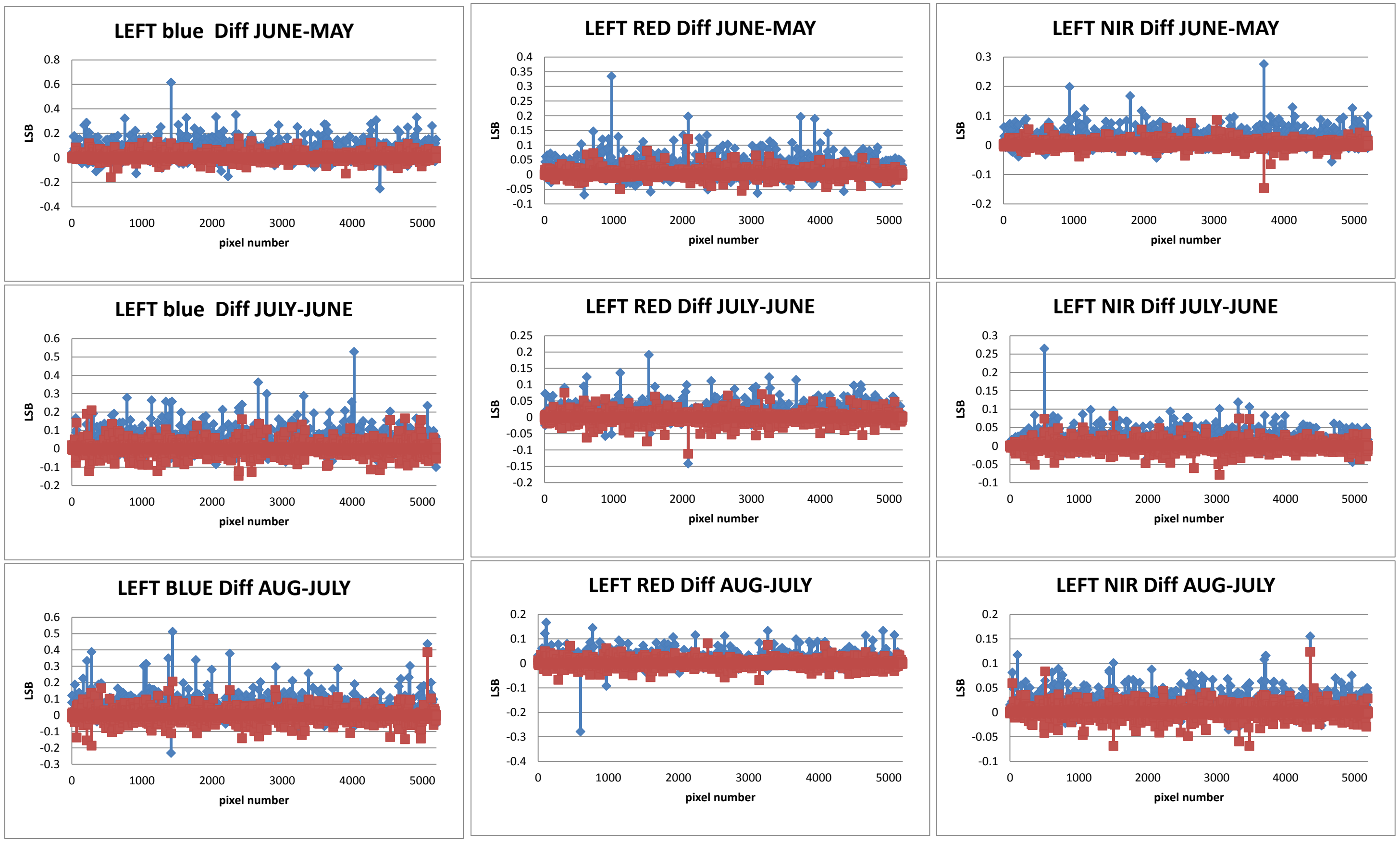


Figure 13. LEFT camera VNIR: Monthly difference (MAY to AUG) in dark current (Blue) and standard deviation (Red) of the monthly averaged results.

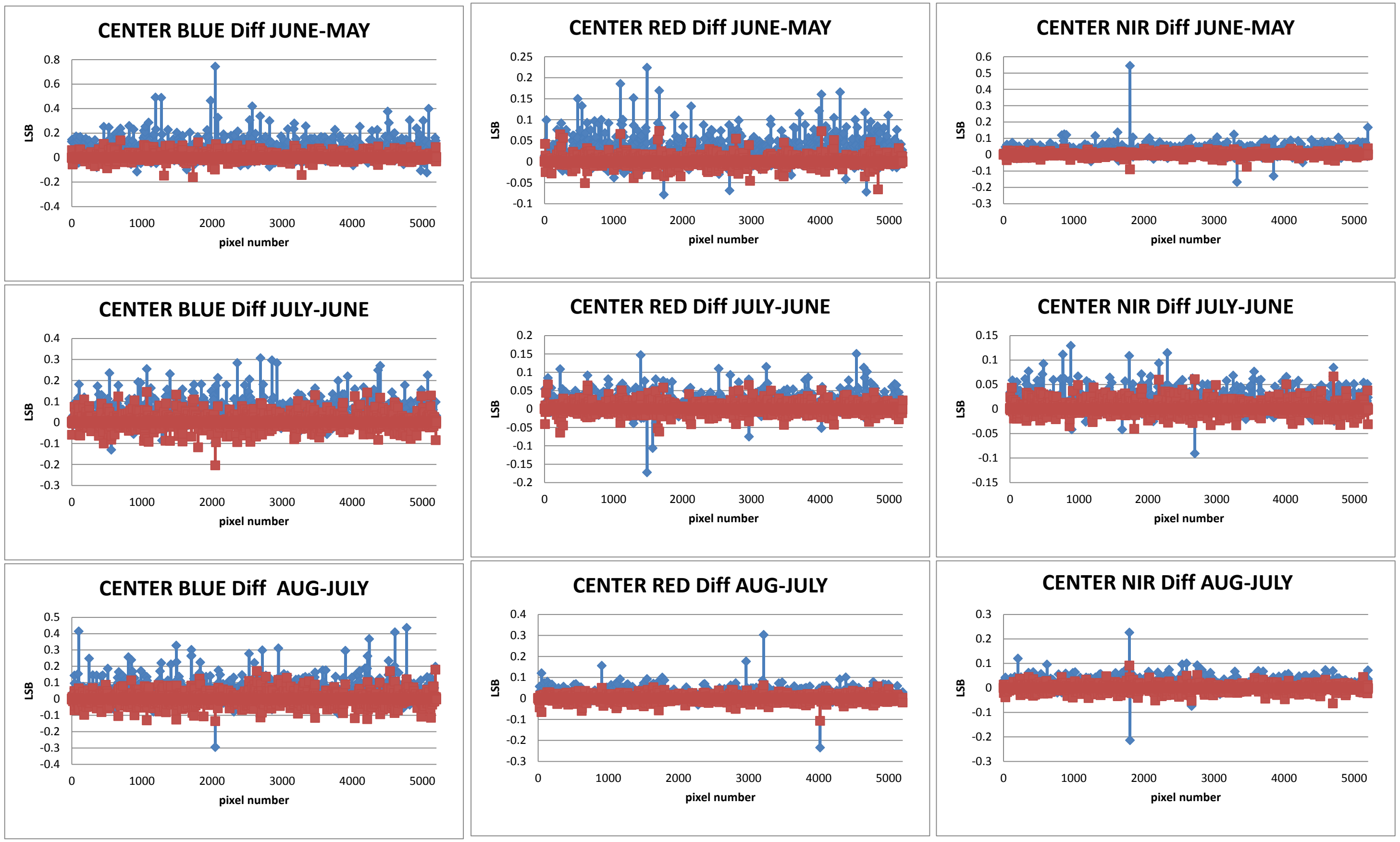


Figure 14. CENTER camera VNIR: Monthly difference (MAY to AUG) in dark current (Blue) and standard deviation (Red) of the monthly averaged results.

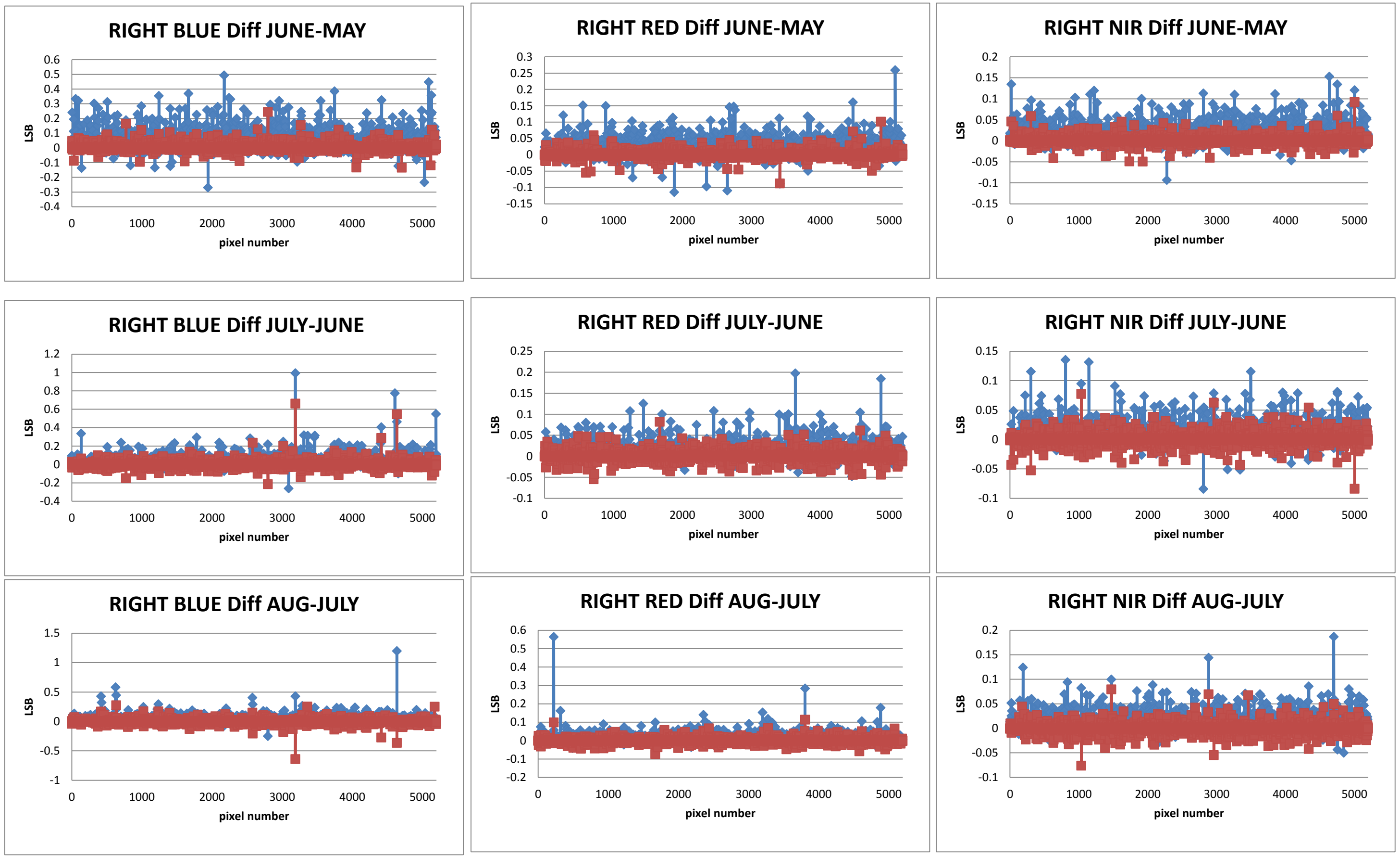


Figure 15. RIGHT camera VNIR: Monthly difference (MAY to AUG) in dark current (Blue) and standard deviation (Red) of the monthly averaged results.

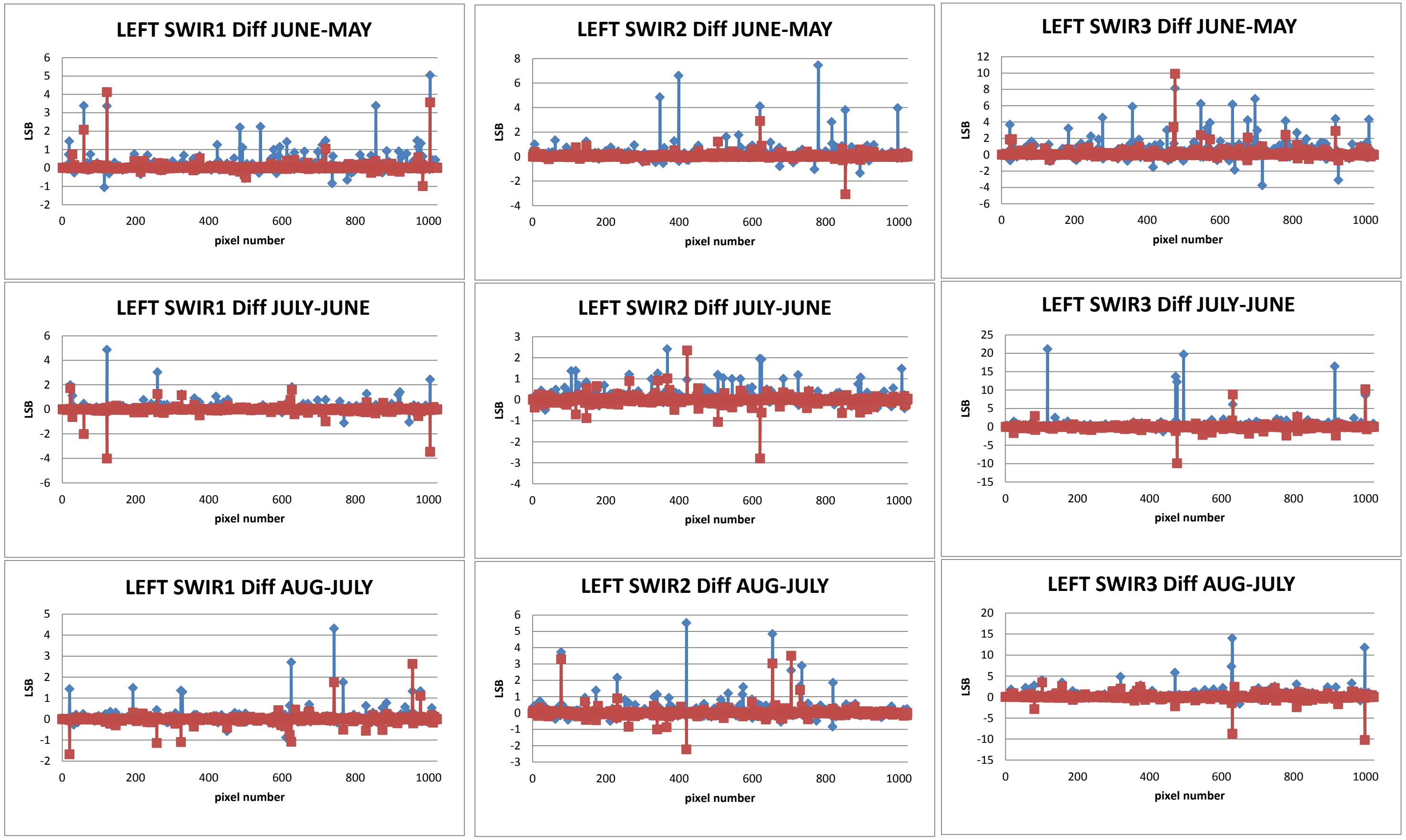


Figure 16. LEFT camera SWIR: Monthly difference (MAY to AUG) in dark current (Blue) and standard deviation (Red) of the monthly averaged results.

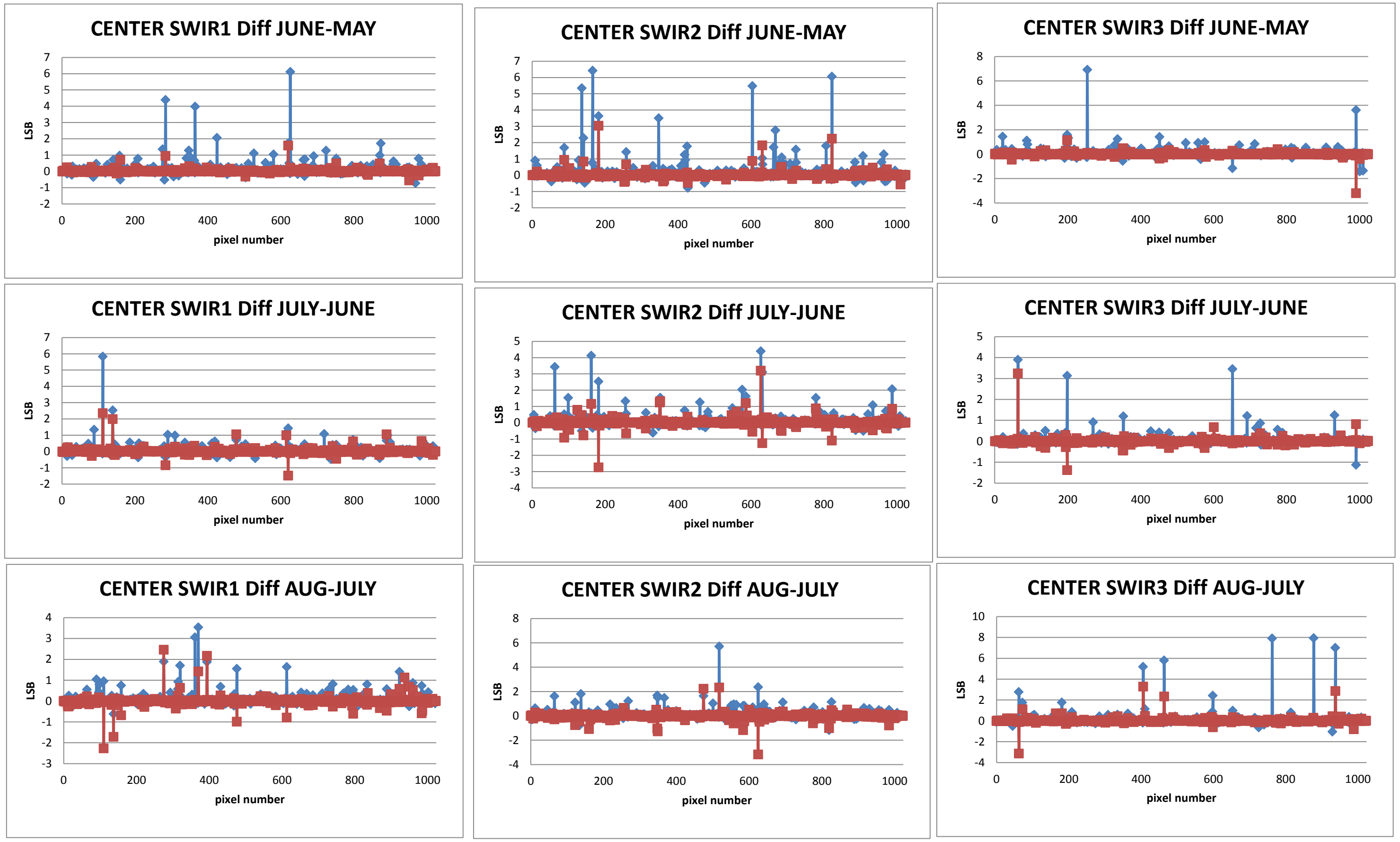


Figure 17. CENTER camera SWIR: Monthly difference (MAY to AUG) in dark current (Blue) and standard deviation (Red) of the monthly averaged results.

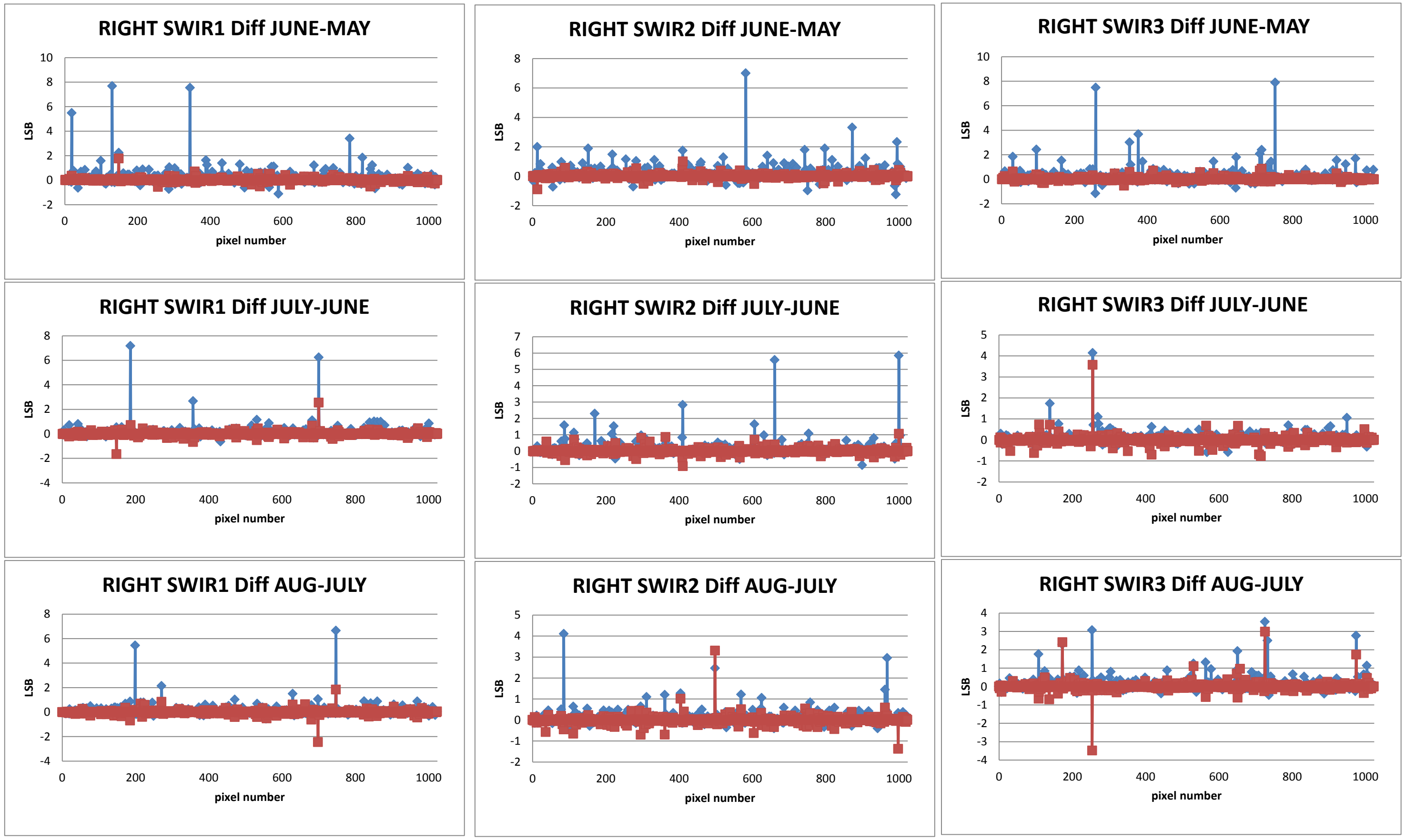


Figure 18. RIGHT camera SWIR: Monthly difference (MAY to AUG) in dark current (Blue) and standard deviation (Red) of the monthly averaged results.

LEFT

APR-MAY-JUNE

SWIR1		SWIR2		SWIR3	
PIXEL ID	STATUS	PIXEL ID	STATUS	PIXEL ID	STATUS
1002	H DC NOK	346	H DC NOK	276	H DC NOK
24	H DC OK	397	H DC NOK	358	H DC NOK
28	H DC OK	619	H DC NOK	453	H DC NOK
31	H DC OK	666	H DC NOK	475	H DC NOK
57	H DC OK	778	H DC NOK	546	H DC NOK
72	H DC OK	897	H DC NOK	633	H DC NOK
250	H DC OK	4	H DC OK	675	H DC NOK
286	H DC OK	35	H DC OK	695	H DC NOK
290	H DC OK	72	H DC OK	779	H DC NOK
298	H DC OK	75	H DC OK	804	H DC NOK
320	H DC OK	102	H DC OK	851	H DC NOK
352	H DC OK	132	H DC OK	916	H DC NOK
424	H DC OK	154	H DC OK	1008	H DC NOK
425	H DC OK	156	H DC OK	156 pixels	H DC OK
504	H DC OK	272	H DC OK		
528	H DC OK	276	H DC OK		
565	H DC OK	283	H DC OK		
644	H DC OK	315	H DC OK		
678	H DC OK	354	H DC OK		
689	H DC OK	378	H DC OK		
748	H DC OK	413	H DC OK		
750	H DC OK	418	H DC OK		
781	H DC OK	419	H DC OK		
783	H DC OK	445	H DC OK		
844	H DC OK	476	H DC OK		
872	H DC OK	481	H DC OK		
982	H DC OK	504	H DC OK		
991	H DC OK	556	H DC OK		
996	H DC OK	587	H DC OK		
1013	H DC OK	600	H DC OK		
		621	H DC OK		
		650	H DC OK		
		676	H DC OK		
		711	H DC OK		
		748	H DC OK		
		757	H DC OK		
		852	H DC OK		
		863	H DC OK		
		892	H DC OK		
		917	H DC OK		
		952	H DC OK		
		975	H DC OK		
		995	H DC OK		
		1004	H DC OK		
		1006	H DC OK		

MAY-JUNE-JULY

SWIR1		SWIR2		SWIR3	
PIXEL ID	STATUS	PIXEL ID	STATUS	PIXEL ID	STATUS
120	H DC NOK	346	H DC NOK	475	H DC BAD
1002	H DC NOK	397	H DC NOK	115	H DC NOK
24	H DC OK	619	H DC NOK	276	H DC NOK
28	H DC OK	778	H DC NOK	358	H DC NOK
31	H DC OK	4	H DC OK	471	H DC NOK
57	H DC OK	35	H DC OK	493	H DC NOK
72	H DC OK	72	H DC OK	546	H DC NOK
250	H DC OK	75	H DC OK	630	H DC NOK
286	H DC OK	102	H DC OK	633	H DC NOK
290	H DC OK	132	H DC OK	675	H DC NOK
298	H DC OK	145	H DC OK	695	H DC NOK
320	H DC OK	154	H DC OK	779	H DC NOK
352	H DC OK	156	H DC OK	913	H DC NOK
424	H DC OK	272	H DC OK	916	H DC NOK
425	H DC OK	276	H DC OK	998	H DC NOK
504	H DC OK	283	H DC OK	1008	H DC NOK
528	H DC OK	315	H DC OK	164 pixels	H DC OK
565	H DC OK	323	H DC OK		
644	H DC OK	327	H DC OK		
678	H DC OK	354	H DC OK		
689	H DC OK	378	H DC OK		
748	H DC OK	385	H DC OK		
750	H DC OK	413	H DC OK		
781	H DC OK	418	H DC OK		
783	H DC OK	419	H DC OK		
844	H DC OK	445	H DC OK		
854	H DC OK	476	H DC OK		
872	H DC OK	481	H DC OK		
982	H DC OK	504	H DC OK		
991	H DC OK	556	H DC OK		
996	H DC OK	587	H DC OK		
1013	H DC OK	600	H DC OK		
		621	H DC OK		
		650	H DC OK		
		666	H DC OK		
		676	H DC OK		
		688	H DC OK		
		711	H DC OK		
		748	H DC OK		
		757	H DC OK		
		852	H DC OK		
		863	H DC OK		
		892	H DC OK		
		897	H DC OK		
		917	H DC OK		
		952	H DC OK		
		975	H DC OK		
		995	H DC OK		
		1004	H DC OK		
		1006	H DC OK		

JUNE-JULY-AUG

SWIR1		SWIR2		SWIR3	
PIXEL ID	STATUS	PIXEL ID	STATUS	PIXEL ID	STATUS
120	H DC NOK	420	H DC NOK	471	H DC BAD
742	H DC NOK	655	H DC NOK	630	H DC BAD
20	H DC OK	4	H DC NOK	998	H DC BAD
24	H DC OK	35	H DC NOK	102	H DC NOK
28	H DC OK	72	H DC OK	115	H DC NOK
31	H DC OK	75	H DC OK	320	H DC NOK
57	H DC OK	78	H DC OK	475	H DC NOK
72	H DC OK	102	H DC OK	493	H DC NOK
250	H DC OK	132	H DC OK	628	H DC NOK
286	H DC OK	145	H DC OK	188 pixels	H DC OK
290	H DC OK	154	H DC OK		
298	H DC OK	156	H DC OK		
320	H DC OK	272	H DC OK		
352	H DC OK	276	H DC OK		
424	H DC OK	283	H DC OK		
425	H DC OK	315	H DC OK		
504	H DC OK	323	H DC OK		
528	H DC OK	327	H DC OK		
565	H DC OK	346	H DC OK		
625	H DC OK	354	H DC OK		
644	H DC OK	378	H DC OK		
678	H DC OK	385	H DC OK		
689	H DC OK	397	H DC OK		
748	H DC OK	413	H DC OK		
750	H DC OK	418	H DC OK		
767	H DC OK	419	H DC OK		
781	H DC OK	445	H DC OK		
783	H DC OK	476	H DC OK		
829	H DC OK	481	H DC OK		
844	H DC OK	504	H DC OK		
854	H DC OK	556	H DC OK		
872	H DC OK	575	H DC OK		
978	H DC OK	587	H DC OK		
982	H DC OK	600	H DC OK		
991	H DC OK	619	H DC OK		
996	H DC OK	621	H DC OK		
1002	H DC OK	650	H DC OK		
1013	H DC OK	666	H DC OK		
		676	H DC OK		
		688	H DC OK		
		711	H DC OK		
		748	H DC OK		
		757	H DC OK		
		778	H DC OK		
		820	H DC OK		
		852	H DC OK		
		863	H DC OK		
		892	H DC OK		
		897	H DC OK		
		917	H DC OK		
		952	H DC OK		
		975	H DC OK		
		995	H DC OK		
		1004	H DC OK		
		1006	H DC OK		

Table 1. LEFT SWIR dark current pixel outliers (ID L1A)

CENTER																	
APR-MAY-JUNE						MAY-JUNE-JULY						JUNE-JULY-AUG					
SWIR1		SWIR2		SWIR3		SWIR1		SWIR2		SWIR3		SWIR1		SWIR2		SWIR3	
PIXEL ID	STATUS	PIXEL ID	STATUS	PIXEL ID	STATUS	PIXEL ID	STATUS	PIXEL ID	STATUS	PIXEL ID	STATUS	PIXEL ID	STATUS	PIXEL ID	STATUS	PIXEL ID	STATUS
39	H DC NOK	134	H DC NOK	252	H DC NOK	110	H DC NOK	134	H DC NOK	252	H DC NOK	110	H DC NOK	160	H DC NOK	406	H DC NOK
282	H DC NOK	164	H DC NOK	0	H DC OK	282	H DC NOK	160	H DC NOK	0	H DC OK	6	H DC OK	518	H DC NOK	464	H DC NOK
624	H DC NOK	602	H DC NOK	23	H DC OK	624	H DC NOK	164	H DC NOK	23	H DC OK	18	H DC OK	15	H DC NOK	763	H DC NOK
6	H DC OK	820	H DC NOK	50	H DC OK	6	H DC OK	602	H DC NOK	50	H DC OK	39	H DC OK	30	H DC OK	878	H DC NOK
18	H DC OK	15	H DC OK	74	H DC OK	18	H DC OK	625	H DC NOK	62	H DC OK	66	H DC OK	55	H DC OK	938	H DC NOK
66	H DC OK	30	H DC OK	144	H DC OK	39	H DC OK	820	H DC NOK	74	H DC OK	128	H DC OK	57	H DC OK	0	H DC OK
128	H DC OK	55	H DC OK	149	H DC OK	66	H DC OK	15	H DC OK	144	H DC OK	164	H DC OK	61	H DC OK	23	H DC OK
164	H DC OK	57	H DC OK	177	H DC OK	128	H DC OK	30	H DC OK	149	H DC OK	200	H DC OK	80	H DC OK	50	H DC OK
200	H DC OK	61	H DC OK	186	H DC OK	164	H DC OK	55	H DC OK	177	H DC OK	211	H DC OK	125	H DC OK	62	H DC OK
211	H DC OK	80	H DC OK	194	H DC OK	200	H DC OK	57	H DC OK	186	H DC OK	216	H DC OK	134	H DC OK	74	H DC OK
216	H DC OK	125	H DC OK	197	H DC OK	211	H DC OK	61	H DC OK	194	H DC OK	265	H DC OK	136	H DC OK	144	H DC OK
265	H DC OK	136	H DC OK	200	H DC OK	216	H DC OK	80	H DC OK	197	H DC OK	282	H DC OK	139	H DC OK	149	H DC OK
299	H DC OK	150	H DC OK	223	H DC OK	265	H DC OK	125	H DC OK	200	H DC OK	299	H DC OK	150	H DC OK	177	H DC OK
304	H DC OK	180	H DC OK	272	H DC OK	299	H DC OK	136	H DC OK	223	H DC OK	304	H DC OK	164	H DC OK	186	H DC OK
343	H DC OK	209	H DC OK	293	H DC OK	304	H DC OK	139	H DC OK	268	H DC OK	309	H DC OK	180	H DC OK	194	H DC OK
350	H DC OK	224	H DC OK	294	H DC OK	309	H DC OK	150	H DC OK	272	H DC OK	320	H DC OK	209	H DC OK	197	H DC OK
363	H DC OK	256	H DC OK	335	H DC OK	343	H DC OK	180	H DC OK	293	H DC OK	343	H DC OK	224	H DC OK	200	H DC OK
387	H DC OK	295	H DC OK	364	H DC OK	350	H DC OK	209	H DC OK	294	H DC OK	350	H DC OK	256	H DC OK	223	H DC OK
444	H DC OK	304	H DC OK	432	H DC OK	363	H DC OK	224	H DC OK	335	H DC OK	361	H DC OK	295	H DC OK	252	H DC OK
448	H DC OK	345	H DC OK	440	H DC OK	387	H DC OK	256	H DC OK	364	H DC OK	363	H DC OK	304	H DC OK	268	H DC OK
451	H DC OK	353	H DC OK	483	H DC OK	444	H DC OK	295	H DC OK	432	H DC OK	370	H DC OK	345	H DC OK	272	H DC OK
604	H DC OK	360	H DC OK	563	H DC OK	448	H DC OK	304	H DC OK	440	H DC OK	387	H DC OK	353	H DC OK	293	H DC OK
641	H DC OK	368	H DC OK	691	H DC OK	451	H DC OK	345	H DC OK	483	H DC OK	444	H DC OK	360	H DC OK	294	H DC OK
644	H DC OK	552	H DC OK	741	H DC OK	604	H DC OK	353	H DC OK	563	H DC OK	448	H DC OK	368	H DC OK	335	H DC OK
792	H DC OK	567	H DC OK	751	H DC OK	641	H DC OK	360	H DC OK	650	H DC OK	451	H DC OK	552	H DC OK	364	H DC OK
831	H DC OK	575	H DC OK	781	H DC OK	644	H DC OK	368	H DC OK	691	H DC OK	604	H DC OK	567	H DC OK	432	H DC OK
938	H DC OK	673	H DC OK	795	H DC OK	792	H DC OK	552	H DC OK	741	H DC OK	613	H DC OK	575	H DC OK	440	H DC OK
947	H DC OK	715	H DC OK	890	H DC OK	831	H DC OK	567	H DC OK	751	H DC OK	624	H DC OK	602	H DC OK	483	H DC OK
961	H DC OK	718	H DC OK	900	H DC OK	938	H DC OK	575	H DC OK	781	H DC OK	641	H DC OK	629	H DC OK	553	H DC OK
964	H DC OK	769	H DC OK	926	H DC OK	947	H DC OK	629	H DC OK	795	H DC OK	644	H DC OK	673	H DC OK	563	H DC OK
967	H DC OK	789	H DC OK	952	H DC OK	961	H DC OK	673	H DC OK	890	H DC OK	792	H DC OK	715	H DC OK	650	H DC OK
1003	H DC OK	804	H DC OK	984	H DC OK	964	H DC OK	715	H DC OK	900	H DC OK	831	H DC OK	718	H DC OK	691	H DC OK
1021	H DC OK	821	H DC OK	989	H DC OK	967	H DC OK	718	H DC OK	926	H DC OK	938	H DC OK	769	H DC OK	741	H DC OK
		881	H DC OK	999	H DC OK	1003	H DC OK	769	H DC OK	952	H DC OK	947	H DC OK	789	H DC OK	751	H DC OK
		885	H DC OK			1021	H DC OK	789	H DC OK	984	H DC OK	961	H DC OK	804	H DC OK	781	H DC OK
		900	H DC OK					804	H DC OK	989	H DC OK	964	H DC OK	820	H DC OK	795	H DC OK
		989	H DC OK					821	H DC OK	999	H DC OK	1003	H DC OK	821	H DC OK	890	H DC OK
								881	H DC OK			1021	H DC OK	881	H DC OK	900	H DC OK
								885	H DC OK					885	H DC OK	926	H DC OK
								900	H DC OK					900	H DC OK	952	H DC OK
								989	H DC OK					989	H DC OK	984	H DC OK
																989	H DC OK
																999	H DC OK

Table 2. CENTER SWIR dark current pixel outliers (ID L1A)

RIGHT																			
APR-MAY-JUNE							MAY-JUNE-JULY							JUNE-JULY-AUG					
SWIR1		SWIR2		SWIR3			SWIR1		SWIR2		SWIR3			SWIR1		SWIR2		SWIR3	
17	H DC NOK	333	H DC NOK	257	H DC NOK		17	H DC NOK	580	H DC NOK	254	H DC NOK		184	H DC NOK	85	H DC NOK	254	H DC NOK
128	H DC NOK	580	H DC NOK	522	H DC NOK		128	H DC NOK	659	H DC NOK	257	H DC NOK		199	H DC NOK	659	H DC NOK	3	H DC OK
342	H DC NOK	944	H DC NOK	750	H DC NOK		184	H DC NOK	998	H DC NOK	750	H DC NOK		698	H DC NOK	998	H DC NOK	46	H DC OK
10	H DC OK	14	H DC OK	46	H DC OK		342	H DC NOK	14	H DC OK	3	H DC OK		747	H DC NOK	14	H DC OK	65	H DC OK
19	H DC OK	23	H DC OK	65	H DC OK		698	H DC NOK	23	H DC OK	46	H DC OK		10	H DC OK	23	H DC OK	78	H DC OK
111	H DC OK	54	H DC OK	78	H DC OK		10	H DC OK	54	H DC OK	65	H DC OK		17	H DC OK	43	H DC OK	94	H DC OK
112	H DC OK	138	H DC OK	94	H DC OK		19	H DC OK	138	H DC OK	78	H DC OK		19	H DC OK	54	H DC OK	119	H DC OK
116	H DC OK	167	H DC OK	119	H DC OK		111	H DC OK	167	H DC OK	94	H DC OK		111	H DC OK	138	H DC OK	237	H DC OK
154	H DC OK	179	H DC OK	228	H DC OK		112	H DC OK	168	H DC OK	119	H DC OK		112	H DC OK	167	H DC OK	242	H DC OK
169	H DC OK	186	H DC OK	237	H DC OK		116	H DC OK	179	H DC OK	228	H DC OK		116	H DC OK	168	H DC OK	257	H DC OK
202	H DC OK	197	H DC OK	242	H DC OK		154	H DC OK	186	H DC OK	237	H DC OK		128	H DC OK	179	H DC OK	271	H DC OK
204	H DC OK	224	H DC OK	271	H DC OK		169	H DC OK	197	H DC OK	242	H DC OK		154	H DC OK	186	H DC OK	340	H DC OK
205	H DC OK	229	H DC OK	340	H DC OK		202	H DC OK	224	H DC OK	271	H DC OK		169	H DC OK	197	H DC OK	374	H DC OK
212	H DC OK	244	H DC OK	374	H DC OK		204	H DC OK	229	H DC OK	340	H DC OK		202	H DC OK	229	H DC OK	449	H DC OK
217	H DC OK	256	H DC OK	449	H DC OK		205	H DC OK	244	H DC OK	374	H DC OK		204	H DC OK	244	H DC OK	465	H DC OK
231	H DC OK	301	H DC OK	465	H DC OK		212	H DC OK	256	H DC OK	449	H DC OK		205	H DC OK	256	H DC OK	522	H DC OK
234	H DC OK	305	H DC OK	559	H DC OK		217	H DC OK	301	H DC OK	465	H DC OK		212	H DC OK	301	H DC OK	559	H DC OK
241	H DC OK	352	H DC OK	576	H DC OK		231	H DC OK	305	H DC OK	522	H DC OK		217	H DC OK	305	H DC OK	576	H DC OK
274	H DC OK	408	H DC OK	623	H DC OK		234	H DC OK	333	H DC OK	559	H DC OK		231	H DC OK	333	H DC OK	623	H DC OK
306	H DC OK	438	H DC OK	650	H DC OK		241	H DC OK	352	H DC OK	576	H DC OK		234	H DC OK	352	H DC OK	650	H DC OK
316	H DC OK	464	H DC OK	741	H DC OK		274	H DC OK	408	H DC OK	623	H DC OK		241	H DC OK	408	H DC OK	713	H DC OK
317	H DC OK	569	H DC OK	791	H DC OK		299	H DC OK	438	H DC OK	650	H DC OK		274	H DC OK	438	H DC OK	726	H DC OK
372	H DC OK	635	H DC OK	810	H DC OK		306	H DC OK	464	H DC OK	741	H DC OK		299	H DC OK	464	H DC OK	741	H DC OK
405	H DC OK	644	H DC OK	838	H DC OK		316	H DC OK	504	H DC OK	791	H DC OK		306	H DC OK	504	H DC OK	750	H DC OK
424	H DC OK	755	H DC OK	894	H DC OK		317	H DC OK	565	H DC OK	810	H DC OK		316	H DC OK	565	H DC OK	791	H DC OK
427	H DC OK	795	H DC OK	919	H DC OK		355	H DC OK	569	H DC OK	838	H DC OK		317	H DC OK	569	H DC OK	810	H DC OK
495	H DC OK	853	H DC OK	934	H DC OK		372	H DC OK	635	H DC OK	894	H DC OK		342	H DC OK	580	H DC OK	838	H DC OK
498	H DC OK	857	H DC OK	939	H DC OK		405	H DC OK	644	H DC OK	919	H DC OK		355	H DC OK	635	H DC OK	894	H DC OK
526	H DC OK	860	H DC OK	971	H DC OK		424	H DC OK	755	H DC OK	934	H DC OK		372	H DC OK	644	H DC OK	919	H DC OK
556	H DC OK	871	H DC OK	973	H DC OK		427	H DC OK	795	H DC OK	939	H DC OK		405	H DC OK	755	H DC OK	934	H DC OK
582	H DC OK	889	H DC OK				495	H DC OK	853	H DC OK	971	H DC OK		424	H DC OK	795	H DC OK	939	H DC OK
598	H DC OK	946	H DC OK				498	H DC OK	857	H DC OK	973	H DC OK		427	H DC OK	853	H DC OK	971	H DC OK
628	H DC OK						526	H DC OK	860	H DC OK				495	H DC OK	857	H DC OK	973	H DC OK
659	H DC OK						556	H DC OK	871	H DC OK				498	H DC OK	860	H DC OK	975	H DC OK
665	H DC OK						582	H DC OK	889	H DC OK				526	H DC OK	871	H DC OK		
676	H DC OK						598	H DC OK	944	H DC OK				556	H DC OK	889	H DC OK		
705	H DC OK						628	H DC OK	946	H DC OK				582	H DC OK	944	H DC OK		
726	H DC OK						659	H DC OK						598	H DC OK	946	H DC OK		
758	H DC OK						665	H DC OK						628	H DC OK				
884	H DC OK						676	H DC OK						659	H DC OK				
918	H DC OK						705	H DC OK						665	H DC OK				
957	H DC OK						726	H DC OK						676	H DC OK				
983	H DC OK						758	H DC OK						705	H DC OK				
985	H DC OK						781	H DC OK						726	H DC OK				
1005	H DC OK						884	H DC OK						758	H DC OK				
1014	H DC OK						918	H DC OK						781	H DC OK				
							957	H DC OK						884	H DC OK				
							983	H DC OK						918	H DC OK				
							985	H DC OK						957	H DC OK				
							1005	H DC OK						983	H DC OK				
							1014	H DC OK						985	H DC OK				
														1005	H DC OK				
														1014	H DC OK				

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

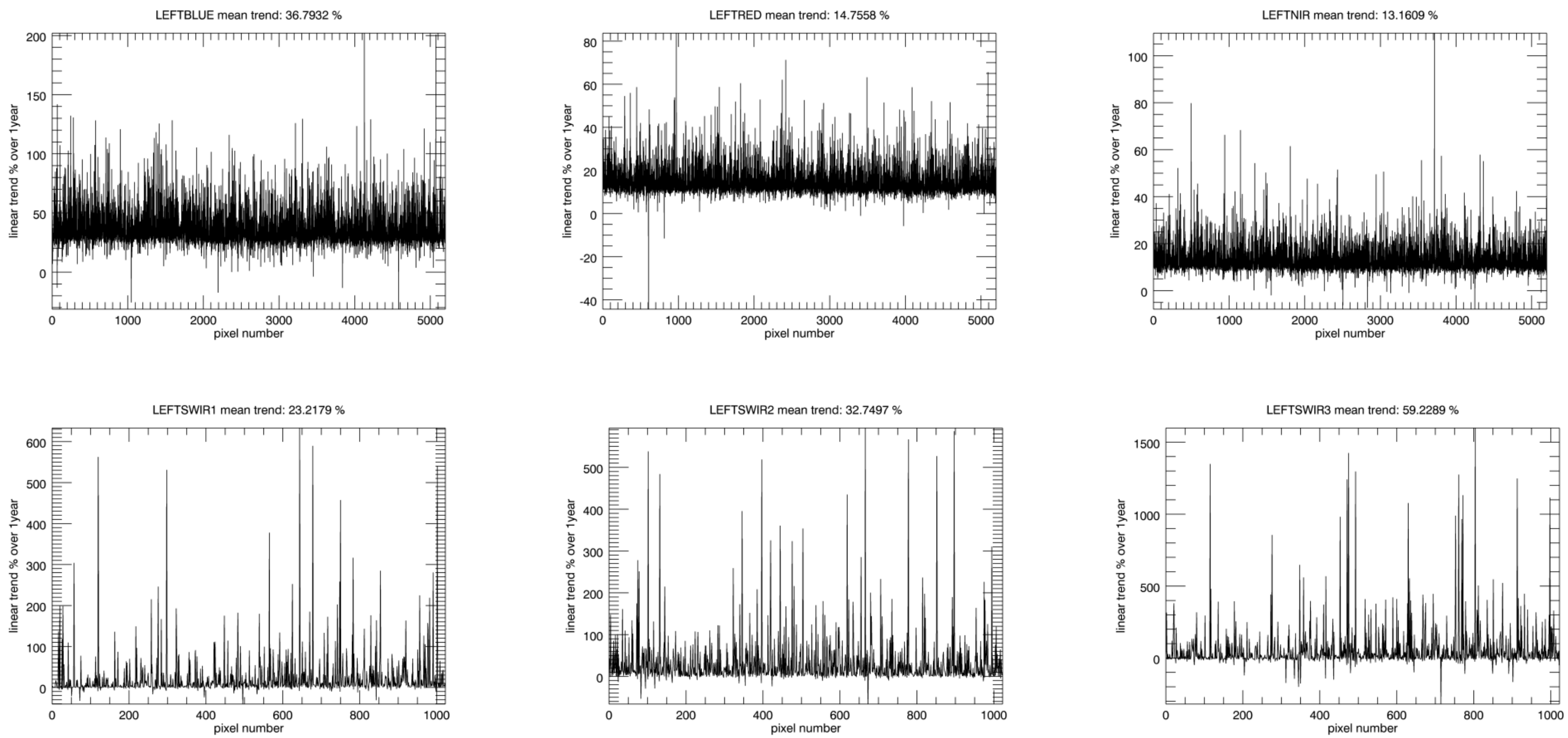


Figure 19. Evolution in dark current extrapolated over 1 year for LEFT camera

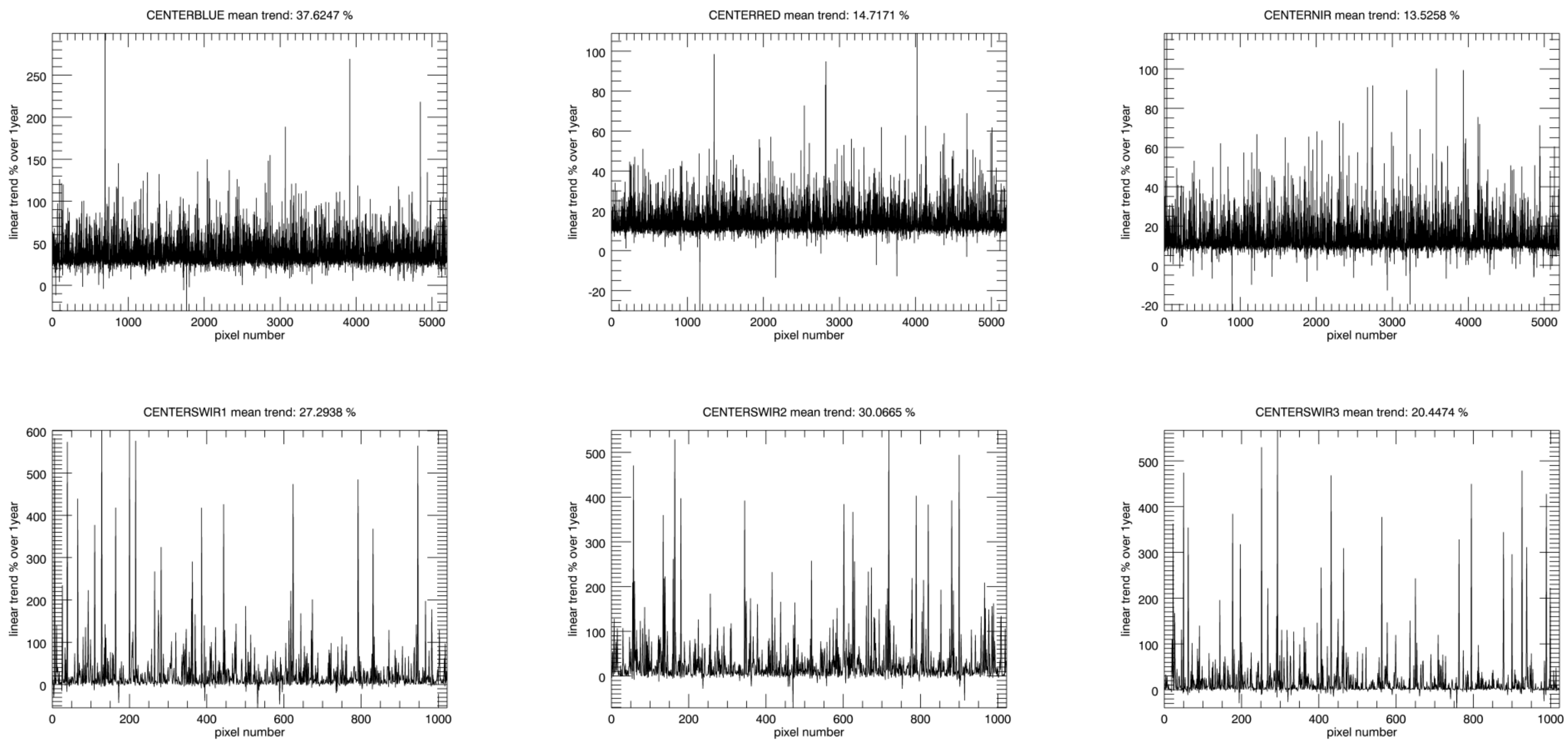


Figure 20. Evolution in dark current over 1 year for CENTER camera

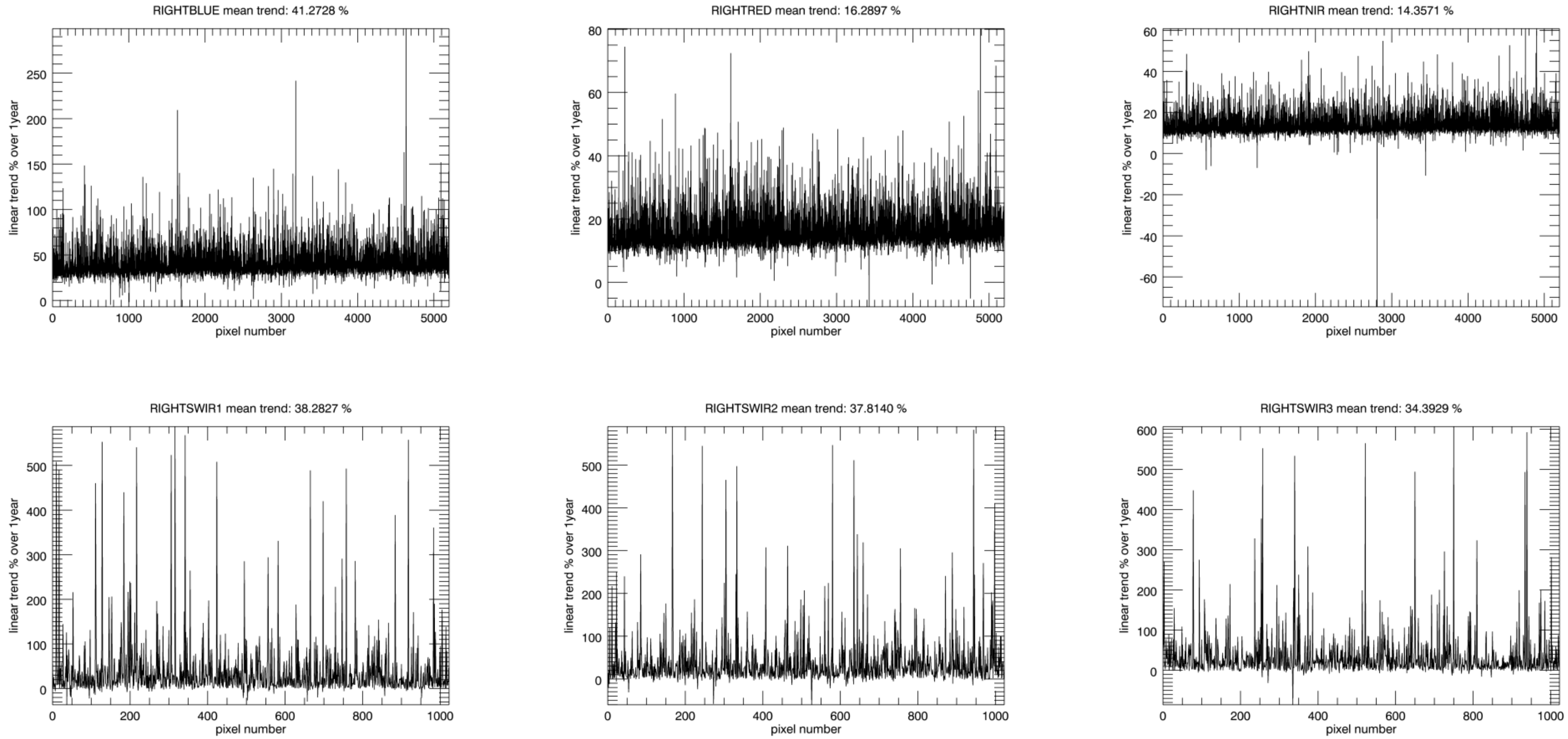


Figure 21. Evolution in dark current over 1 year for RIGHT camera

1.4. High Frequency Equalisation/Striping

Methodology

The high frequency interpixel variation or equalization differences are estimated on radiometrically corrected images i.e. the radiometric model is applied including the equalization coefficients (gi). If they are correct, they remove all the pixel to pixel non-uniformity. In principle the multi-angular method then detects no non-uniformities, only noise if systematic non-uniformities are detected, they can be viewed as corrections to the existing equalization coefficients ($\Delta gi, high$). Working like this is in fact an advantage as it focuses entirely on the changes from the existing coefficients. The coefficients can be updated by multiplying the new estimates ("correction coefficients") with the old ones:

$$gi, new = gi\ x\Delta gi, high$$

The $\Delta gi, high$ are estimated as follows:

- An input image is taken, containing as little variation in the scene as possible. Image containing uniform snow areas over Antarctica or Greenland during local summer are ideal for VNIR bands. For SWIR bands images over homogeneous desert sites (e.g. Libya4) are used.
- Low pass image: is obtained by calculating an averaging filter in the along track direction.
- HFRR (high frequency relative response) image is the ratio between the original and the low pass image. It contains only the high frequency information.
- In the HFRR image, the trimmed mean is calculated in the along track direction (using all pixel values of a column).
- The average and standard deviation over the considered time period is calculated.

Results

The overall equalization ($\Delta gi, high$) profile results for the VNIR bands are shown in Figure 22, Figure 23 and Figure 24 for respectively LEFT, CENTER and RIGHT camera.
The graphs at the top show the high frequency profile values ($\Delta gi, high$) per pixel in red, and the values plus and minus 1 standard deviation (estimated using the robust MAD statistic) in light blue.
The graphs at the bottom show scattergrams which reveal the relation between the estimated $\Delta gi, high$ values and their stdevs. The scattergrams allow inspecting in a convenient way which pixels can be considered as outliers.

The $\Delta gi, high$ VNIR values are in average lower than in previous quarterly report. This probably due to the fact that for the last reporting period less optimal acquisitions were used. For the current period the equalisation profiles have been obtained from acquisitions over Greenland. There are no VNIR pixels with $\Delta gi, high$ values larger than 1.005 (in contrast to previous report).

For the SWIR bands the equalisation analysis is done monthly over the Libya4 desert region due to observed larger $\Delta gi, high$ values and the occurrence (and possible increase of) bad pixels. For SWIR bands a pixels is marked as suspect when the $\Delta gi, high$ exceeds 3 %. The $\Delta gi, high$

results/plots for the left camera are given in Figure 25Figure 26 and Figure 27 for respectively the July, August and September analysis. For the centre camera results are given in Figure 28, Figure 29 and Figure 30. For the right camera in Figure 31, Figure 32 and Figure 33.

The August SWIR analysis revealed 2 bad pixels; the September analysis 1 bad pixel. They were added to the bad pixel status map. In total there are now 20 SWIR pixels with the status BAD. These are listed in Table 4.

Every month an update of the SWIR equalisation values in the ICP file was performed, as reported in Table 5, in order to reduce striping. It has been noted that stripes (due to light response change of a single SWIR pixel) can suddenly appear in the image, requiring regular updates of equalisation coefficients.

mid July				
		pixel numbers (ID L1A)		
CAMERA	**STRIP**	**new BAD**	**Suspect (Δg > 2%)**	**old BAD**
LEFT	SWIR1		120 , 1002	28,298,352,644
LEFT	SWIR2		778	711,863
LEFT	SWIR3			438,759,761
CENTER	SWIR1			1021
CENTER	SWIR2			57,295,769,900
CENTER	SWIR3			890
RIGHT	SWIR1			
RIGHT	SWIR2			14,438
RIGHT	SWIR3			

mid AUG				
		pixel numbers (ID L1A)		
CAMERA	**STRIP**	**new BAD**	**Suspect (Δg > 2%)**	**old BAD**
LEFT	SWIR1		120	28,298,352,644
LEFT	SWIR2			711,863
LEFT	SWIR3		115	438,759,761
CENTER	SWIR1			1021
CENTER	SWIR2			57,295,769,900
CENTER	SWIR3	763,938		890
RIGHT	SWIR1			
RIGHT	SWIR2			14,438
RIGHT	SWIR3			

mid SEPT				
		pixel numbers (ID L1A)		
CAMERA	**STRIP**	**new BAD**	**Suspect (Δg > 2%)**	**old BAD**
LEFT	SWIR1	**956**		28,298,352,644
LEFT	SWIR2			711,863
LEFT	SWIR3		115	438,759,761
CENTER	SWIR1			1021
CENTER	SWIR2			57,295,769,900
CENTER	SWIR3			890 , 763,938
RIGHT	SWIR1			
RIGHT	SWIR2			14,438
RIGHT	SWIR3		726	

Table 4 Suspect and BAD 'equalisation' pixels SWIR

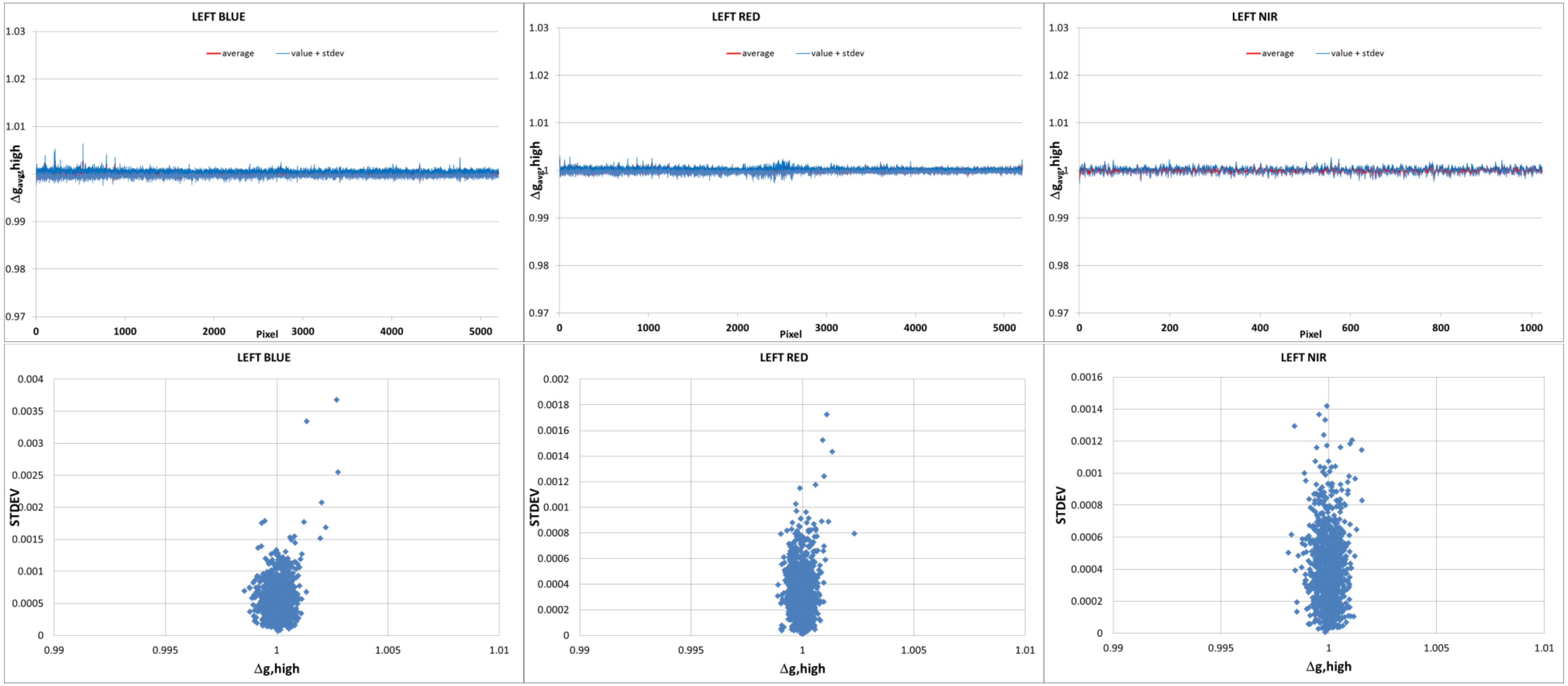


Figure 22. HF VNIR equalisation results LEFT

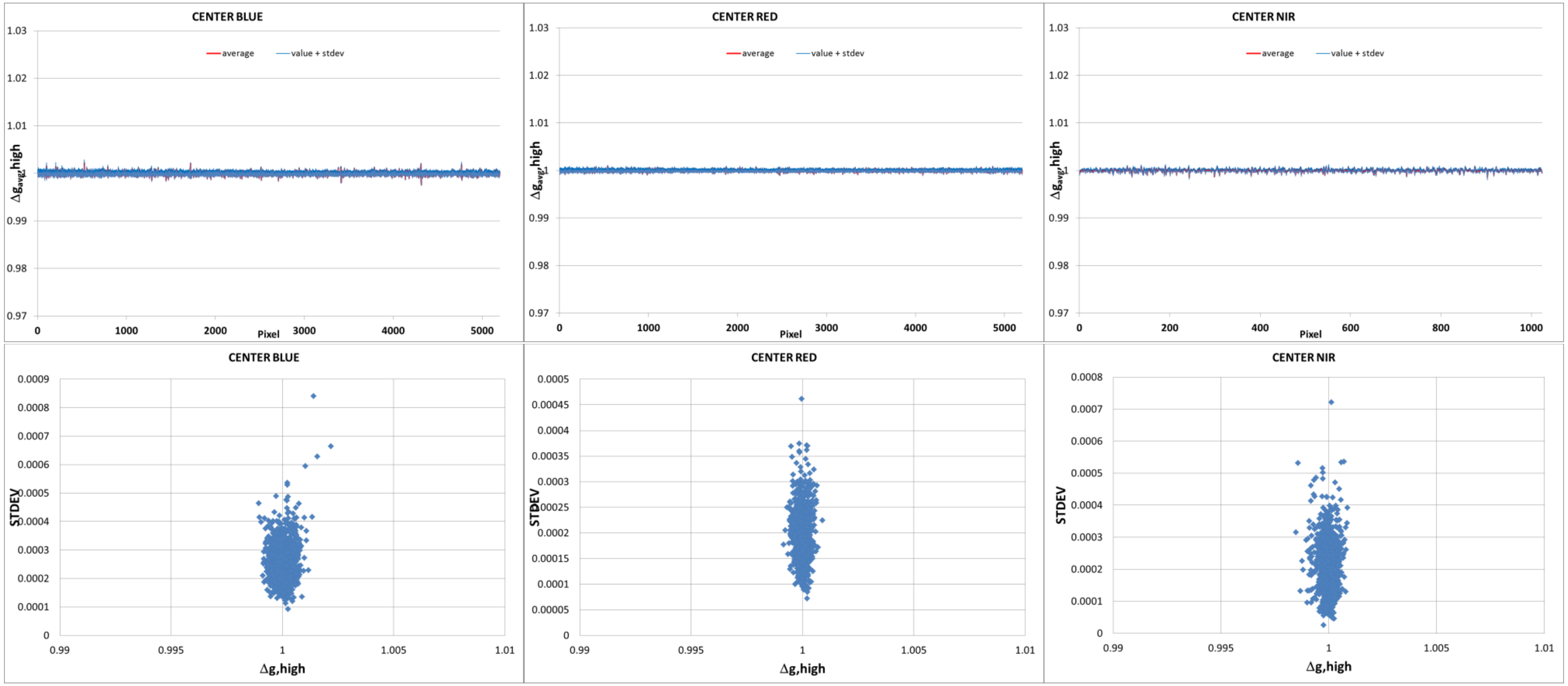


Figure 23. HF VNIR equalisation results CENTER

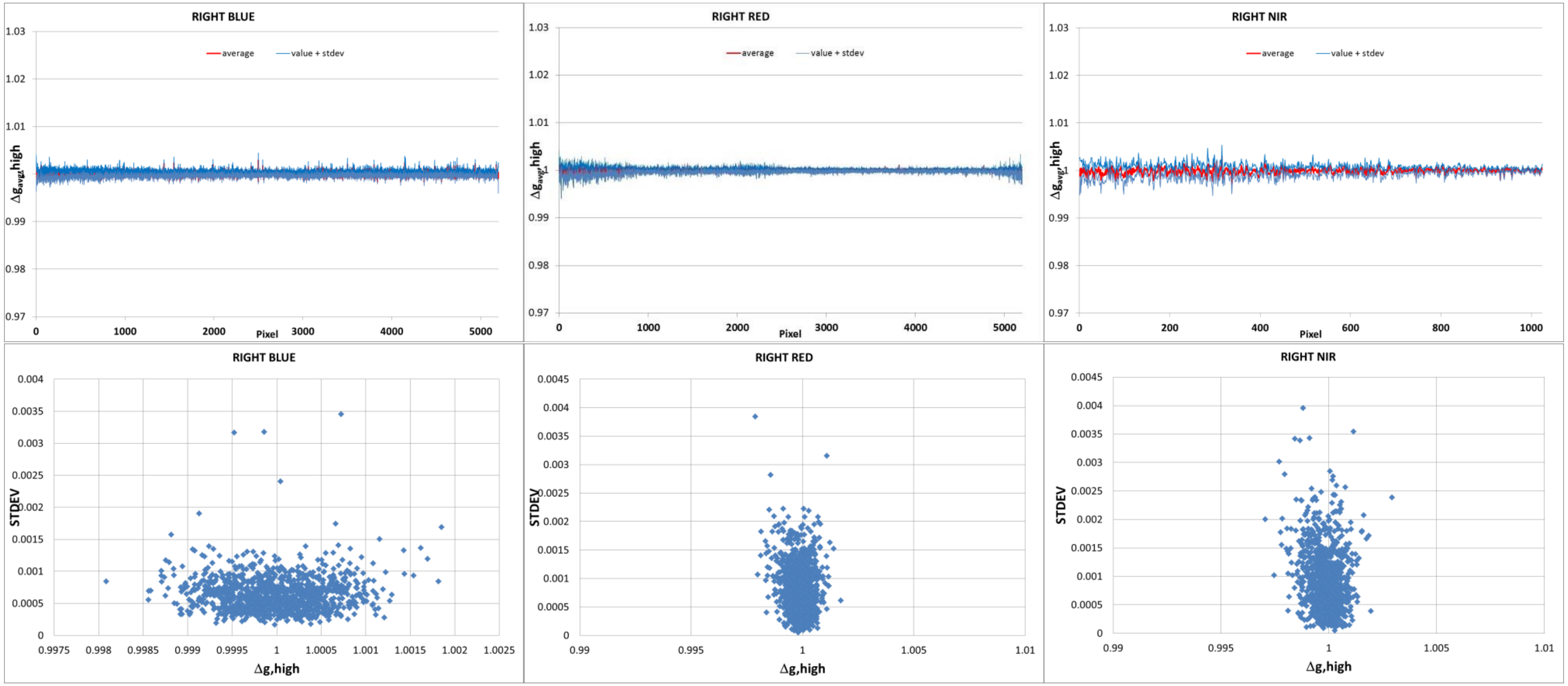


Figure 24. HF VNIR equalisation results RIGHT

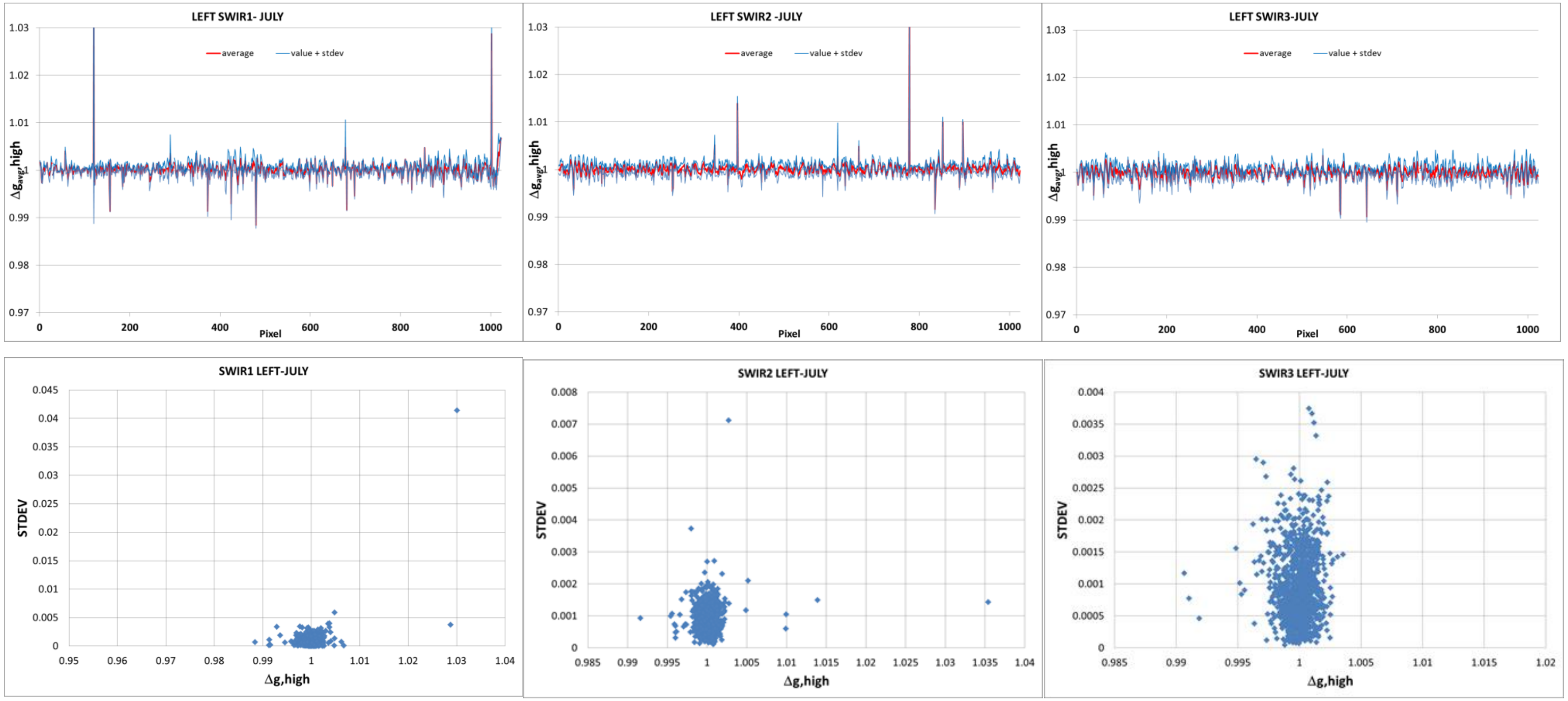


Figure 25. HF SWIR equalisation results SWIR LEFT: mid-June to mid-July

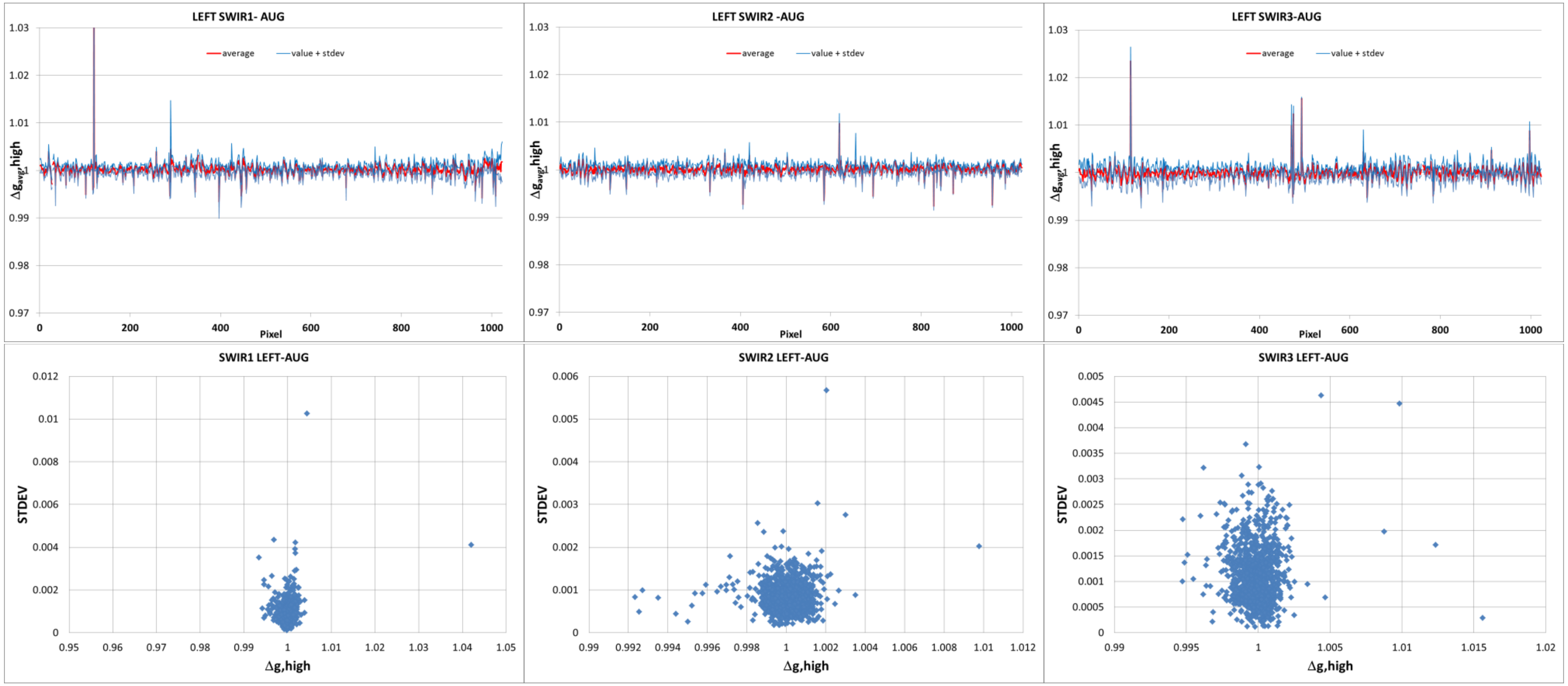


Figure 26. HF SWIR equalisation results SWIR LEFT: mid-July to Mid-Aug with equalisation update of 18 July

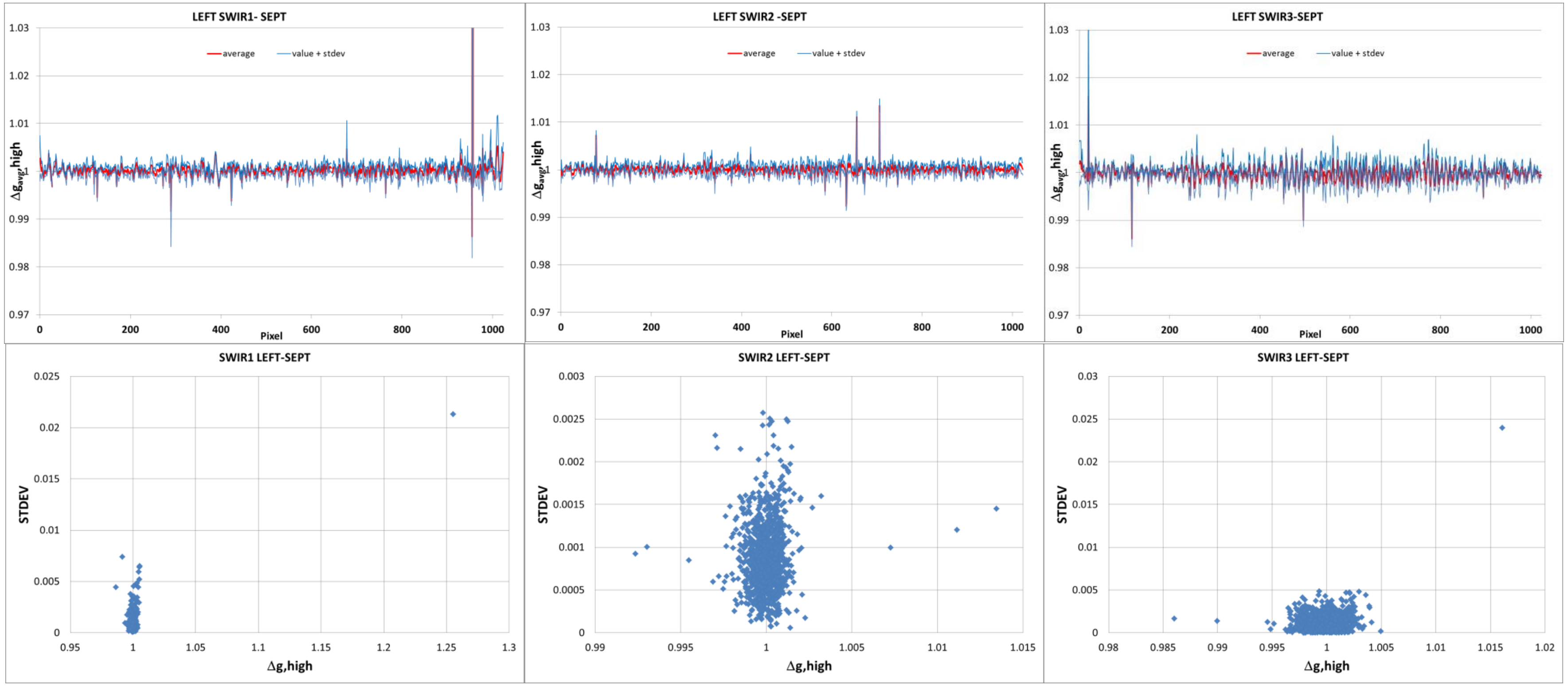


Figure 27. HF SWIR equalisation results SWIR LEFT: Sept analysis with equalisation update of 26 Aug.

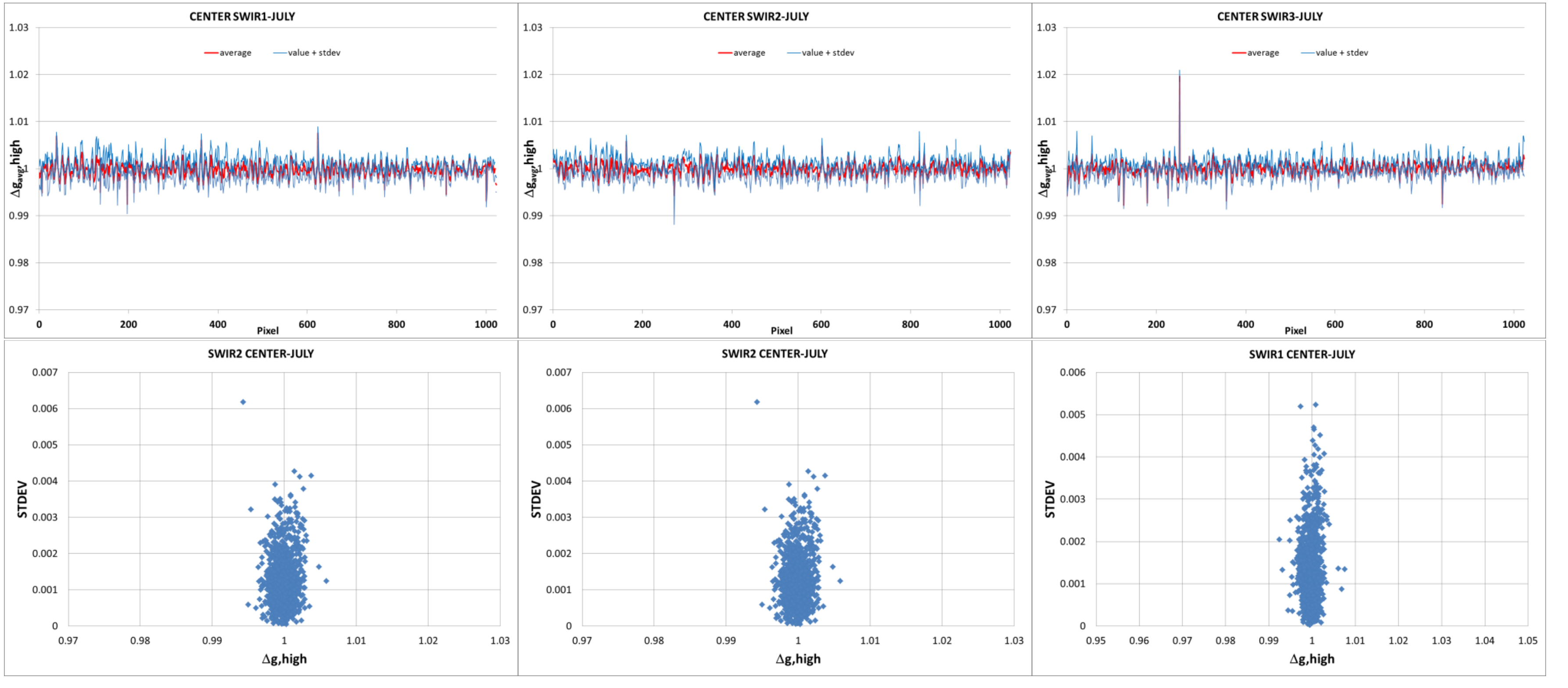


Figure 28. HF SWIR equalisation results SWIR CENTER mid-June to mid-July

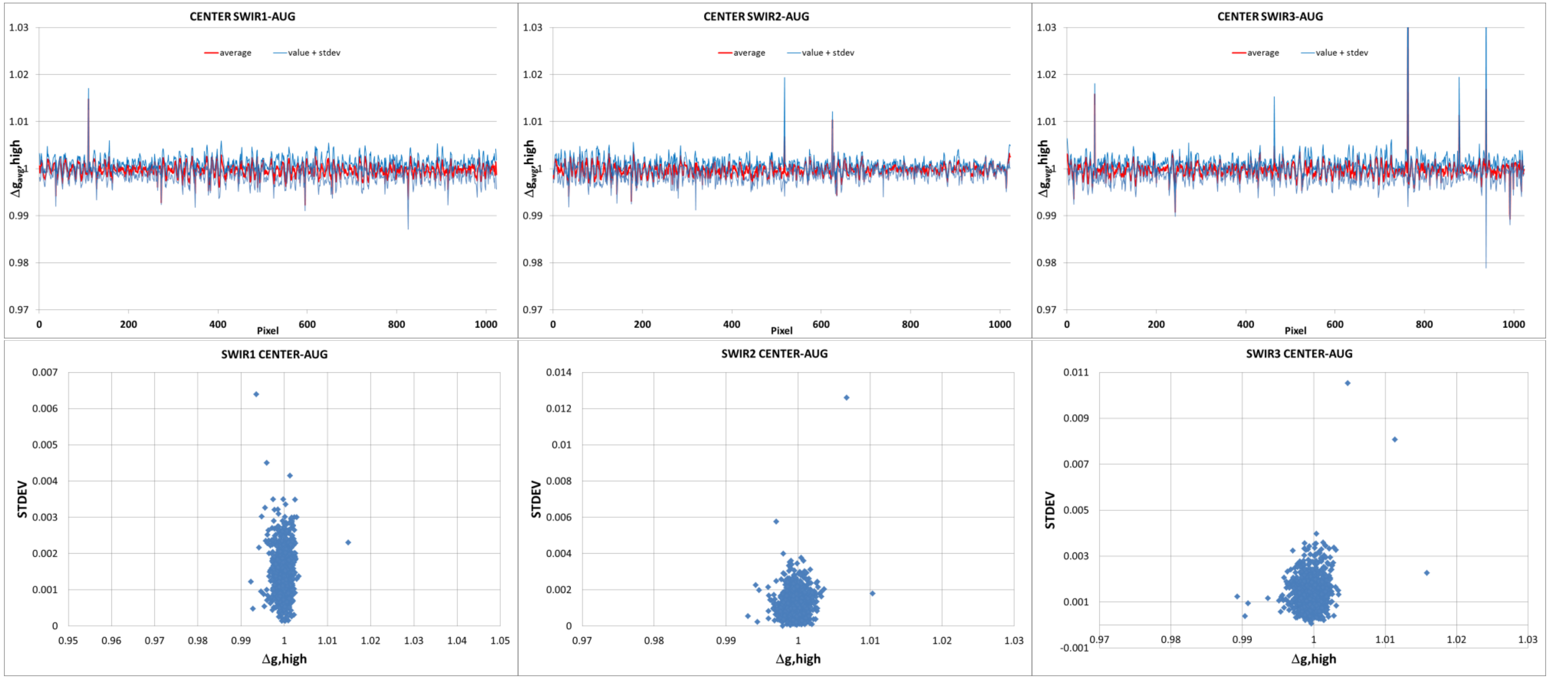


Figure 29. HF SWIR equalisation results SWIR CENTER mid-July to Mid-Aug with equalisation update of 18 July

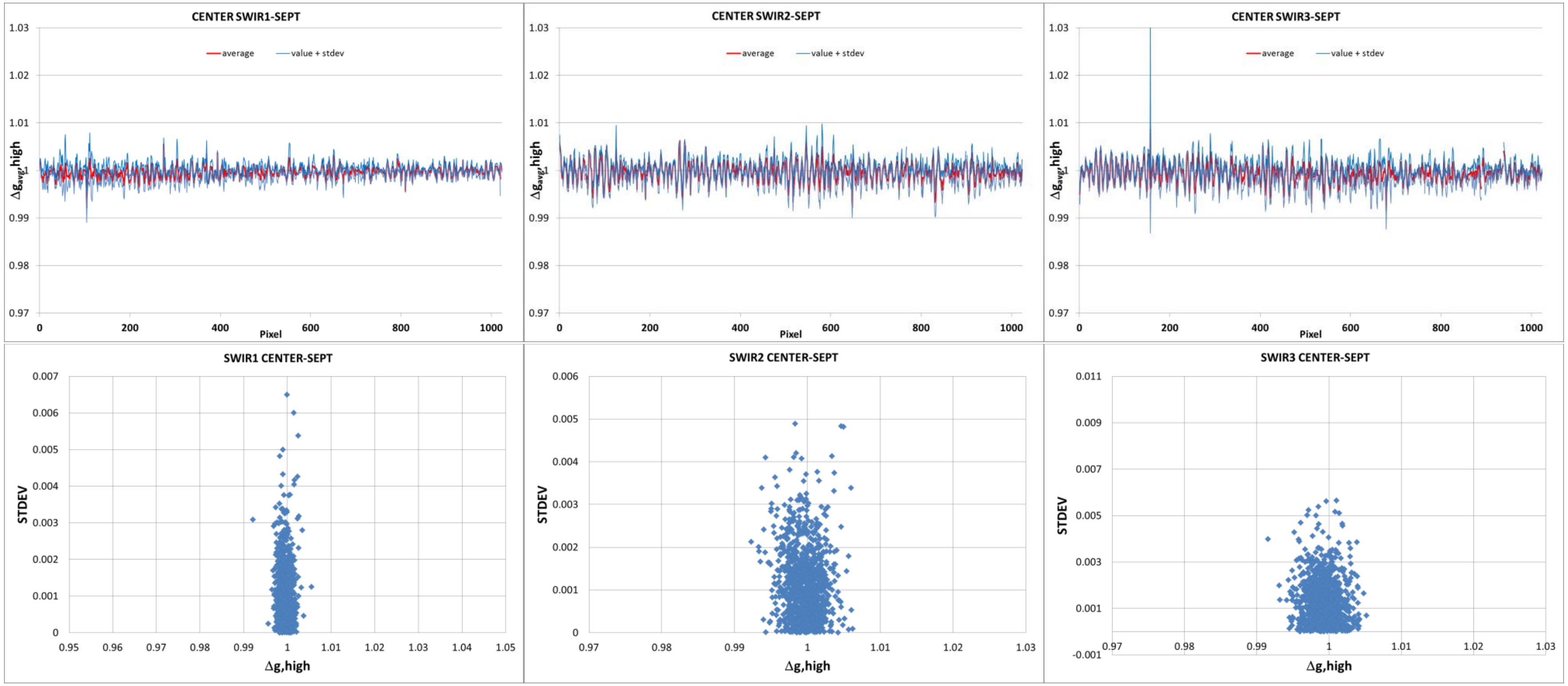


Figure 30. HF SWIR equalisation results SWIR CENTER Sept analysis with equalisation update of 26 Aug

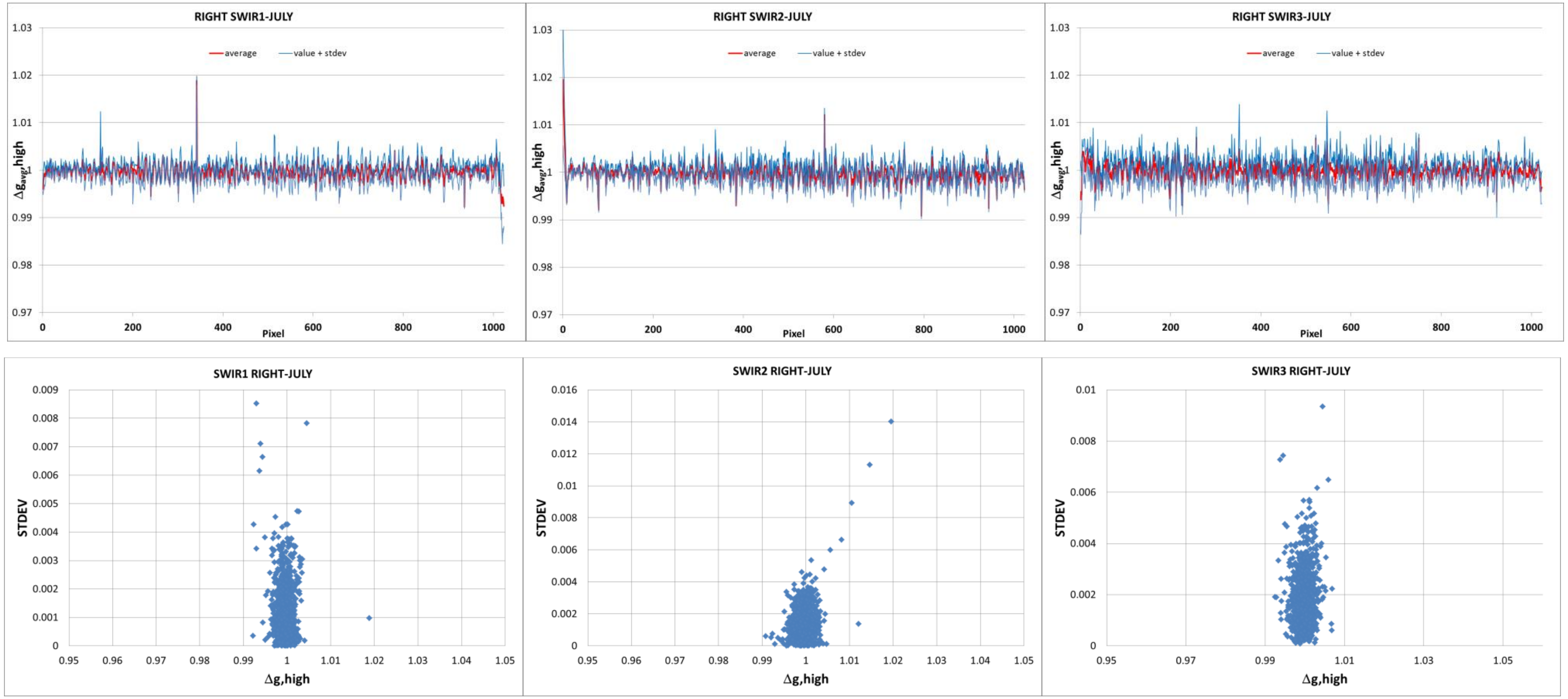


Figure 31. HF SWIR equalisation results SWIR RIGHT mid-June to mid-July

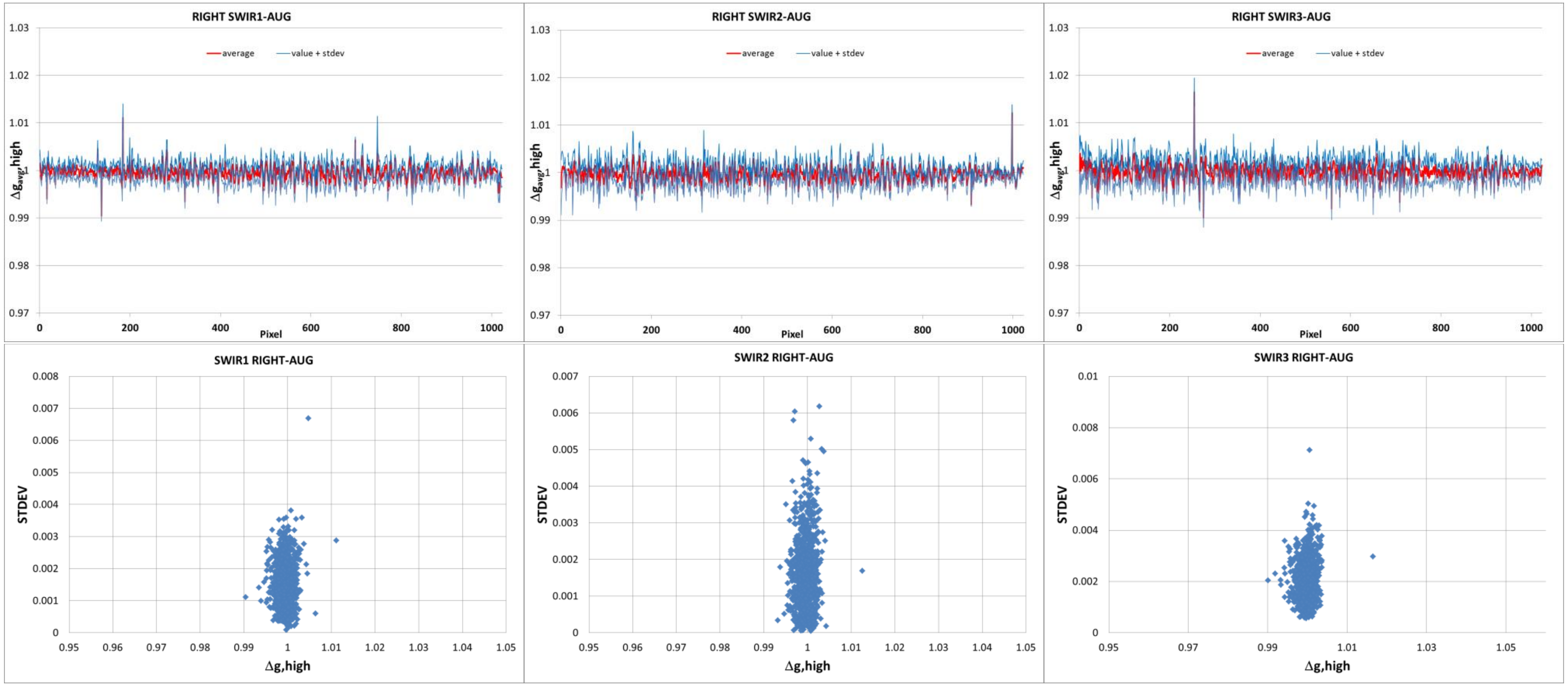


Figure 32. HF SWIR equalisation results SWIR RIGHT: mid-July to Mid-Aug with equalisation update of 18 July

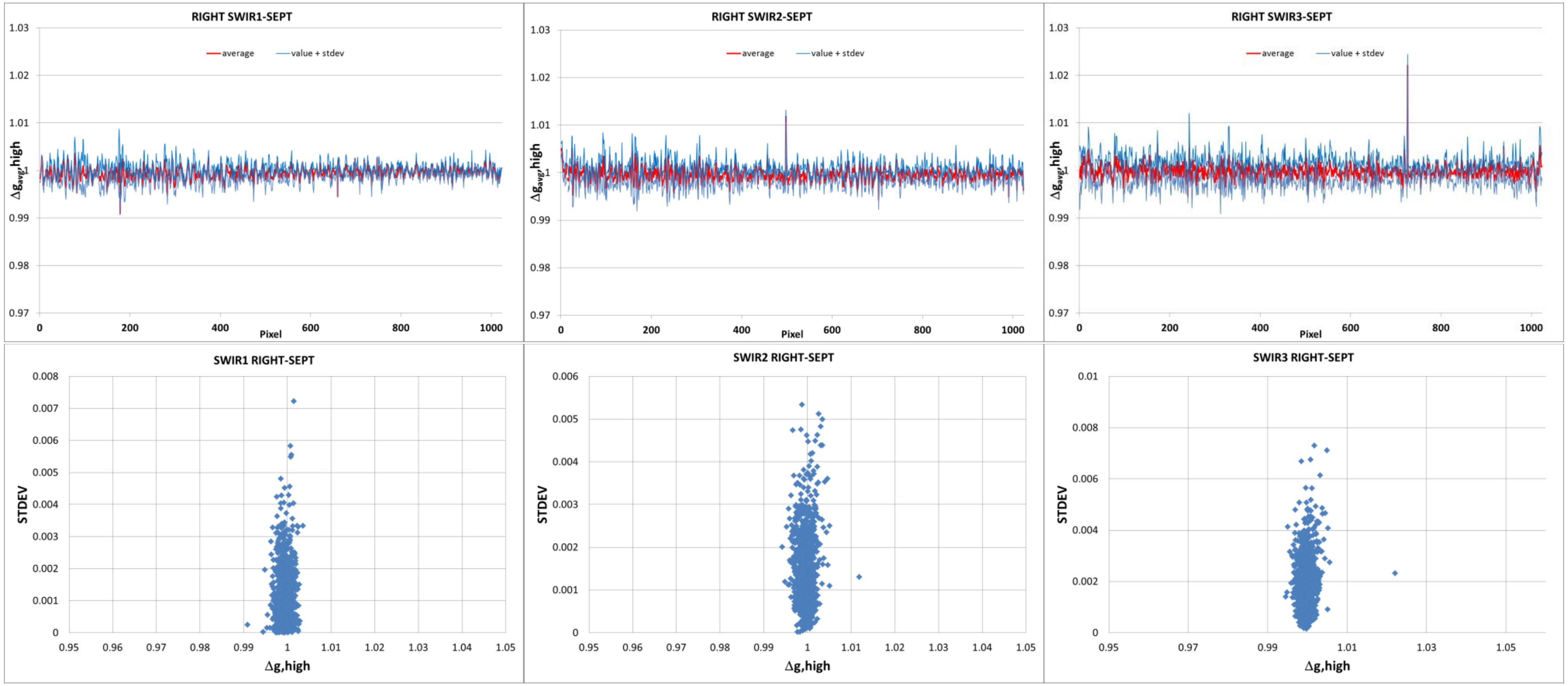


Figure 33. HF SWIR equalisation results SWIR RIGHT Sept analysis with equalisation update of 26 Aug

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 below

ICP filename	Description
PROBAV_X_R_000_20140116.xml	Update of offset and NL values provided by OIP at end of the commissioning phase
PROBAV_X_R_000_20140215.xml	Update of VNIR and SWIR dark currents
PROBAV_X_R_000_20140219.xml	Update of SWIR equalizations
PROBAV_X_R_000_20140322.xml	Update of VNIR and SWIR dark currents , SWIR status map update : one bad pixel added
PROBAV_X_R_000_20140419.xml	Update of VNIR and SWIR dark currents , SWIR status map update : five bad pixel added
PROBAV_X_R_000_20140529.xml	Update of VNIR and SWIR dark currents , Update of SWIR equalizations
PROBAV_X_R_000_20140626.xml	Update of VNIR and SWIR dark currents ,update of absolute blue **CENTER and RIGHT**
PROBAV_X_R_000_20140718.xml	Update of VNIR and SWIR dark currents , Update of SWIR equalizations
PROBAV_X_R_000_20140826.xml	Update of VNIR and SWIR dark currents , Update of SWIR equalizations, SWIR status map update : two bad pixels added
PROBAV_X_R_000_201409xx.xml	Update of absolute calibration coefficient **BLUE LEFT, NIR LEFT, RED CENTER**, Update of VNIR and SWIR dark currents , Update of SWIR equalizations, SWIR status map update : one bad pixel added

Table 5: Radiometric ICP-file updates

2. Geometric Image Quality

2.1. Summary

The average daily average location error compliance (ALE<300m) was stable and at the level of 99.9%.

The monthly average location error remained stable (1σ standard deviation < 47m) and below 63m for all spectral bands (all cameras).

Lower geometric quality performance was observed between 28.08.2014 and 02.09.2014, when the average daily location error increased to 117m (1σ standard deviation < 60m). The source of this temporal geometric deterioration is unknown. Analysis of the telemetry data by ESA and QinetiQ did not bring any cues. Since 03.09.2014 onwards the geometric Proba-V performance is back to average.

The inter-band geometric accuracy remained stable and ranged from 0.08 to 0.14 of a pixel (333m).

In this reporting period the multi-temporal geometric accuracy was at the level of 95.4% for the VNIR sensor and 99.3% for the VNIR/SWIR combined.

The overall multi-temporal geometric accuracy (last 6 months) is at the level of 95.2% for the VNIR sensor and 99.3% for the VNIR/SWIR combined.

The geometric ICP file created on the 24nd of March 2014 (after the startracker patch was applied) remains valid and applicable.

Since 09.09.2014 onwards Landsat GLS2010 is used as reference data in the geometric validation chain of PROBA-V (instead of GLS2000).

2.2. Assessment of the geometric accuracy on L1C data

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

CAMERA 1 Mean ALE (m)			
Strip\Period	16/06/2014 - 15/07/2014	16/07/2014 - 15/08/2014	16/08/2014 - 15/09/2014
BLUE	77.1, std = 60.8	84.0, std = 68.8	76.6, std = 35.0
RED	76.8, std = 70.39	84.6, std = 78.5	74.6, std = 40.9
NIR	78.4, std = 53.5	83.0, std = 54.6	72.6, std = 40.8
SWIR1	82.9, std = 61.4	88.7, std = 67.5	80.6, std = 53.1
SWIR2	60.3, std = 35.0	61.6, std = 34.9	68.0, std = 48.7
SWIR3	45.7, std = 18.7	44.9, std = 18.4	47.0 , std = 31.0

Table 6: Mean absolute location error for camera 1.

CAMERA 2 Mean ALE (m)			
Strip\Period	16/06/2014 - 15/07/2014	16/07/2014 - 15/08/2014	16/08/2014 - 15/09/2014
BLUE	59.1, std = 55.0	63.0, std = 61.3	58.4, std = 52.1
RED	53.3, std = 45.8	56.3, std = 49.2	52.4, std = 40.7
NIR	48.2, std = 28.9	50.0, std = 31.3	49.5, std = 28.6
SWIR1	65.1, std = 57.0	60.6, std = 47.4	62.6, std = 53.7
SWIR2	50.3, std = 24.1	49.9, std = 23.5	49.7, std = 22.5
SWIR3	43.6, std = 18.0	42.7, std = 17.4	45.1, std = 17.5

Table 7: Mean absolute location error for camera 2.

CAMERA 3 Mean ALE (m)			
Strip\Period	16/06/2014 - 15/07/2014	16/07/2014 - 15/08/2014	16/08/2014 - 15/09/2014
BLUE	58.9, std = 53.3	60.4, std = 52.4	57.5, std = 46.8
RED	56.9, std = 45.1	59.4, std = 44.4	56.8, std = 40.8
NIR	53.2, std = 29.9	55.4, std = 30.7	54.1, std = 28.9
SWIR1	66.0, std = 55.7	64.1, std = 49.9	66.5, std = 53.8
SWIR2	53.7, std = 26.2	54.8, std =27.3	54.2, std = 24.6
SWIR3	73.3, std = 58.9	77.3, std = 58.2	77.6, std = 55.8

Table 8: Mean absolute location error for camera 3.

In the reporting period the average location error of the Level 1C data remained at the level of 62m on average. That result is comparable (1% increase) to the results stated in the previous report.

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 16/06/2014 to 15/07/2014
- from 16/07/2014 to 15/08/2014
- from 16/08/2014 to 15/09/2014

The tables list:

- The day of the measurement in format dd/mm/yyyy

- 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
16/06/2014	99.91	99.86	99.80	99.99	22085	57.20	39.92	24176	57.86	39.00	22425	63.04	49.98	15924	60.57	45.72
17/06/2014	99.90	99.90	99.80	99.98	23314	61.68	47.35	25028	62.80	46.36	22743	67.74	49.28	17208	66.27	48.85
18/06/2014	99.92	99.93	99.93	99.99	23827	54.05	43.06	26412	54.08	43.85	24163	56.93	38.44	17557	57.40	41.71
19/06/2014	99.94	99.95	99.92	99.98	24869	53.21	34.96	27533	53.08	37.11	25784	56.14	37.55	18482	56.09	43.75
20/06/2014	99.89	99.89	99.88	99.96	23700	57.76	56.76	24615	57.83	39.97	19115	60.66	40.70	14216	59.43	47.77
21/06/2014	99.91	99.87	99.73	100.00	23767	64.62	44.60	25885	66.78	46.90	23184	71.53	50.14	17264	66.78	44.82
22/06/2014	99.82	99.86	99.68	99.98	24100	70.81	45.64	26967	72.12	45.00	21099	80.08	51.23	15837	75.89	47.61
23/06/2014	99.87	99.90	99.81	99.98	26243	65.12	49.20	28187	64.96	42.07	24241	71.13	47.68	18302	68.87	46.84
24/06/2014	99.92	99.94	99.89	99.96	22077	62.07	42.72	26771	60.23	35.76	20102	65.90	41.83	14166	65.15	49.03
25/06/2014	99.87	99.88	99.85	99.96	24084	62.50	44.25	27869	63.03	44.22	25392	67.22	44.11	17043	67.42	60.55
26/06/2014	99.90	99.93	99.87	99.96	24368	60.40	42.88	27359	61.02	39.27	24684	67.47	43.52	16931	66.45	56.64
27/06/2014	99.95	99.91	99.85	99.99	24581	61.84	41.88	26570	61.49	42.20	25035	66.18	47.03	17883	66.14	41.94
28/06/2014	99.90	99.88	99.83	99.96	24160	58.32	38.36	26849	57.52	41.93	24089	59.84	44.32	17882	62.31	52.75
29/06/2014	99.92	99.92	99.85	99.96	24828	56.36	35.58	26714	56.60	38.84	22968	57.72	39.82	17409	60.89	57.10
30/06/2014	99.04	98.82	98.77	99.79	22969	67.75	59.23	24745	67.10	59.82	21317	70.13	58.70	15979	71.69	61.09
1/07/2014	99.91	99.93	99.90	99.98	25442	55.43	45.10	28098	53.83	38.84	23557	57.68	40.43	18402	61.66	42.05
2/07/2014	99.90	99.92	99.89	99.99	25725	51.52	39.64	29414	49.41	33.48	26027	52.36	38.90	19088	57.28	42.98
3/07/2014	99.94	99.93	99.89	99.98	24715	52.90	45.35	28192	52.09	39.61	24381	56.65	45.78	18088	58.52	42.45
4/07/2014	99.88	99.85	99.81	99.91	22190	60.35	44.84	24721	60.74	46.98	21602	66.39	48.95	14824	67.67	60.20
5/07/2014	99.92	99.93	99.90	99.99	24539	55.07	41.30	27157	55.94	37.10	23123	60.99	42.50	16044	62.31	41.70
6/07/2014	99.95	99.94	99.92	99.98	23772	51.94	37.06	25874	51.94	44.38	22201	56.35	38.75	16727	55.45	36.59
7/07/2014	99.93	99.95	99.93	99.99	23579	54.12	38.31	26229	53.75	40.26	23002	56.14	37.77	17842	55.65	41.75
8/07/2014	99.90	99.92	99.90	99.97	22172	53.39	37.93	24343	54.14	41.16	20195	54.98	38.86	14479	56.05	47.08
9/07/2014	99.92	99.96	99.86	99.97	42135	54.64	41.08	45265	54.66	37.27	38747	57.21	44.14	28618	59.54	50.73
10/07/2014	99.51	99.45	99.42	99.91	23836	57.92	47.38	26101	58.34	49.59	23032	59.53	54.72	16848	60.49	48.58
11/07/2014	99.92	99.94	99.92	99.99	25287	52.23	44.82	27363	51.15	43.02	24757	52.11	42.15	18017	54.24	39.67
12/07/2014	99.91	99.97	99.91	99.96	25241	49.32	36.25	29013	47.32	34.21	26561	48.84	37.87	18430	53.11	41.71
13/07/2014	99.89	99.96	99.95	99.99	22640	50.70	39.31	26625	48.34	38.19	24289	50.45	39.63	16207	55.55	41.19
14/07/2014	99.93	99.94	99.94	99.99	21538	50.53	37.94	25811	48.44	37.36	23437	51.38	41.40	15975	53.59	41.20
15/07/2014	99.91	99.93	99.92	99.98	22326	50.48	41.59	25653	48.95	36.96	22432	50.73	44.53	16179	51.98	37.42
Averages	**99.87**	**99.87**	**99.82**	**99.97**	**24470.3**	**57.14**	**42.81**	**27184.6**	**56.85**	**41.36**	**23789.5**	**60.45**	**44.02**	**17261.7**	**61.15**	**46.71**

Table 9: Daily achieved compliance and the daily average location error (in m) for all spectral bands in the period 16/06/2014 to 15/07/2014.

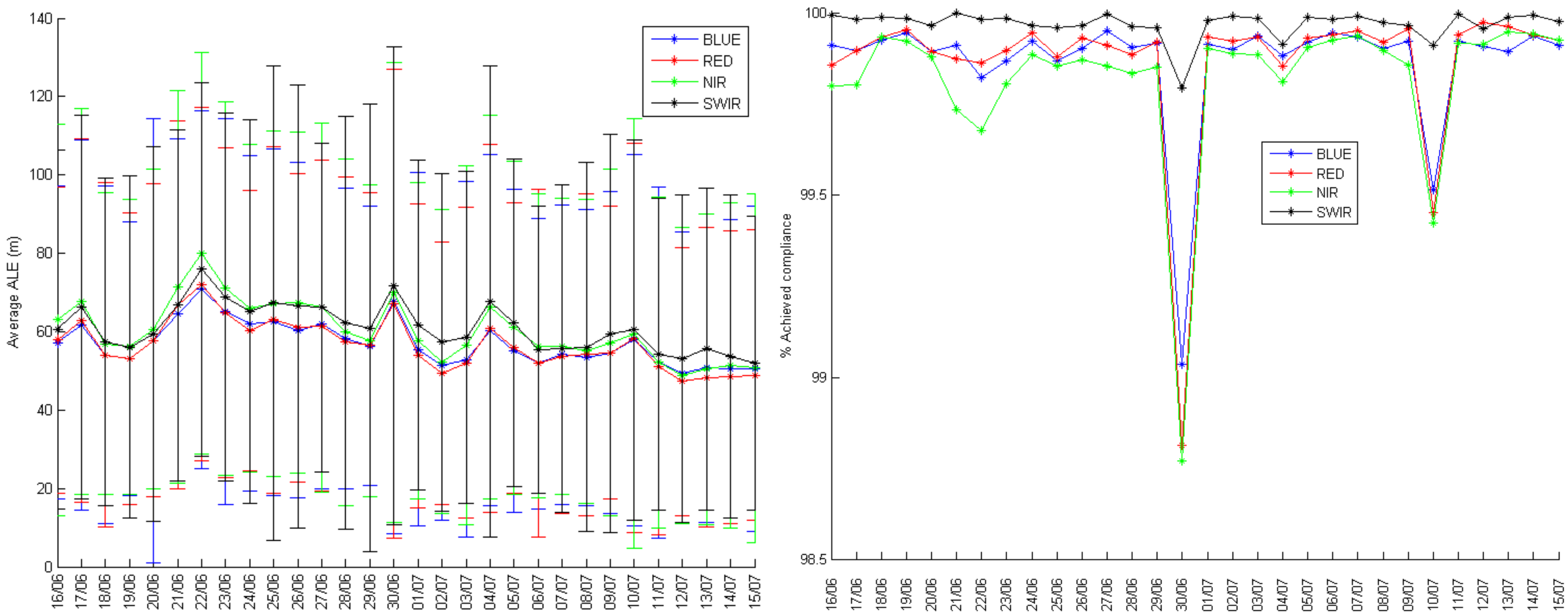


Figure 34: Daily average location error for all spectral bands in the period from 16/06/2014 to 15/07/2014 (left). The average daily compliance of the spectral bands (right).

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
16/07/2014	99.92	99.95	99.90	99.99	21736	50.43	42.24	24483	49.43	35.16	22632	51.87	44.55	17060	53.37	37.09
17/07/2014	99.90	99.94	99.95	99.99	21932	50.79	44.10	25622	49.16	35.65	23359	49.95	36.89	16124	52.90	38.40
18/07/2014	99.95	99.96	99.91	100.00	19867	50.96	38.72	22498	51.55	34.29	20492	55.39	45.77	14402	55.31	37.32
19/07/2014	99.90	99.95	99.91	99.98	15965	53.67	49.13	18383	53.04	34.39	16237	56.82	40.21	10871	57.28	43.66
20/07/2014	99.80	99.84	99.81	99.96	19461	67.22	55.67	21462	66.22	44.18	19017	69.86	48.96	14376	67.86	52.86
21/07/2014	99.76	99.82	99.75	99.98	20424	79.74	52.83	22931	79.98	47.86	20482	81.39	52.38	15946	78.65	55.53
22/07/2014	99.45	99.55	99.36	99.96	20575	81.81	60.70	23030	81.12	57.32	20973	82.49	59.08	14788	82.54	60.77
23/07/2014	99.76	99.76	99.73	99.99	21530	76.48	51.23	24027	77.17	52.82	21521	79.09	52.40	15510	79.89	49.55
24/07/2014	99.86	99.87	99.86	99.99	23097	66.50	50.89	25353	65.88	48.06	22759	67.71	45.85	16216	68.32	42.28
25/07/2014	99.86	99.86	99.78	99.98	22925	65.08	50.53	25713	64.83	44.60	22982	66.00	44.59	16956	64.84	40.93
26/07/2014	99.85	99.81	99.82	99.97	23540	58.09	40.86	26208	57.68	42.51	23440	58.47	43.86	16796	57.74	44.87
27/07/2014	99.94	99.92	99.91	99.99	25613	54.07	37.45	28332	53.44	45.97	24774	54.70	42.29	17805	57.56	44.39
28/07/2014	99.90	99.92	99.89	99.97	21875	57.61	45.44	24400	56.40	43.32	21716	60.63	46.94	15692	61.58	47.07
29/07/2014	99.90	99.92	99.87	99.99	23195	55.44	44.34	25828	55.46	43.63	23947	59.70	45.07	18145	57.79	38.84
30/07/2014	99.88	99.92	99.90	99.99	22726	53.38	53.52	25834	51.86	37.24	23721	55.62	44.18	17607	55.58	43.39
31/07/2014	99.95	99.96	99.93	99.98	22111	55.61	39.46	25351	53.38	41.85	22670	54.77	37.74	15966	56.73	44.10
1/08/2014	99.94	99.85	99.67	99.97	21267	63.15	45.21	24021	62.99	43.14	22243	64.93	55.28	14771	68.08	52.86
2/08/2014	99.87	99.92	99.89	99.98	22522	63.87	48.75	26412	62.85	41.39	24150	65.46	54.67	16140	68.21	58.02
3/08/2014	99.91	99.94	99.94	99.98	22910	58.42	49.26	26669	56.16	37.01	25202	57.67	38.62	18139	59.01	44.48
4/08/2014	99.91	99.96	99.92	99.99	20357	55.48	41.19	24596	52.50	34.22	24437	54.97	40.31	16080	56.92	43.22
5/08/2014	99.90	99.91	99.87	99.99	34230	59.99	44.28	39752	58.61	49.37	33139	63.47	53.10	23921	64.64	46.94
6/08/2014	99.93	99.93	99.93	99.95	22786	63.37	40.38	26366	61.32	42.07	24046	65.21	46.80	16780	66.96	54.47
7/08/2014	99.90	99.93	99.92	99.99	22176	59.00	45.99	24844	57.33	41.22	23174	60.73	40.60	16945	60.89	39.69
8/08/2014	99.92	99.94	99.88	99.97	20970	55.89	41.85	23937	54.81	36.07	21924	57.59	47.93	17196	58.13	41.15
9/08/2014	99.94	99.92	99.86	99.99	20638	59.03	37.52	23627	59.91	41.71	20461	63.01	47.64	15773	62.79	45.47
10/08/2014	99.89	99.89	99.77	99.99	21755	67.55	49.28	23724	69.51	46.99	20518	72.89	52.65	15718	70.55	46.70
11/08/2014	99.92	99.88	99.82	99.99	14197	65.80	46.92	16247	66.58	50.70	13661	69.94	44.44	9740	70.67	44.34
12/08/2014	99.88	99.93	99.90	99.99	22735	59.19	54.46	25721	59.12	39.69	23379	61.62	40.16	17173	61.19	44.99
13/08/2014	99.87	99.94	99.90	99.98	22619	55.39	41.19	25927	54.47	41.34	24793	56.97	43.77	17827	56.97	45.99
14/08/2014	99.87	99.88	99.84	99.99	22154	59.03	47.53	25728	59.43	46.80	23715	62.39	46.05	16972	62.09	45.88
15/08/2014	99.93	99.91	99.92	99.98	23026	55.40	40.35	26781	55.65	39.27	23897	59.84	39.74	17697	59.80	48.90
Averages	**99.88**	**99.89**	**99.85**	**99.98**	**21965.0**	**60.56**	**46.17**	**24961.5**	**59.93**	**42.58**	**22563.3**	**62.62**	**45.89**	**16294.6**	**63.06**	**45.94**

Table 10: Daily achieved compliance and the daily average location error (in m) for all spectral bands in the period 16/07/2014 to 15/08/2014.

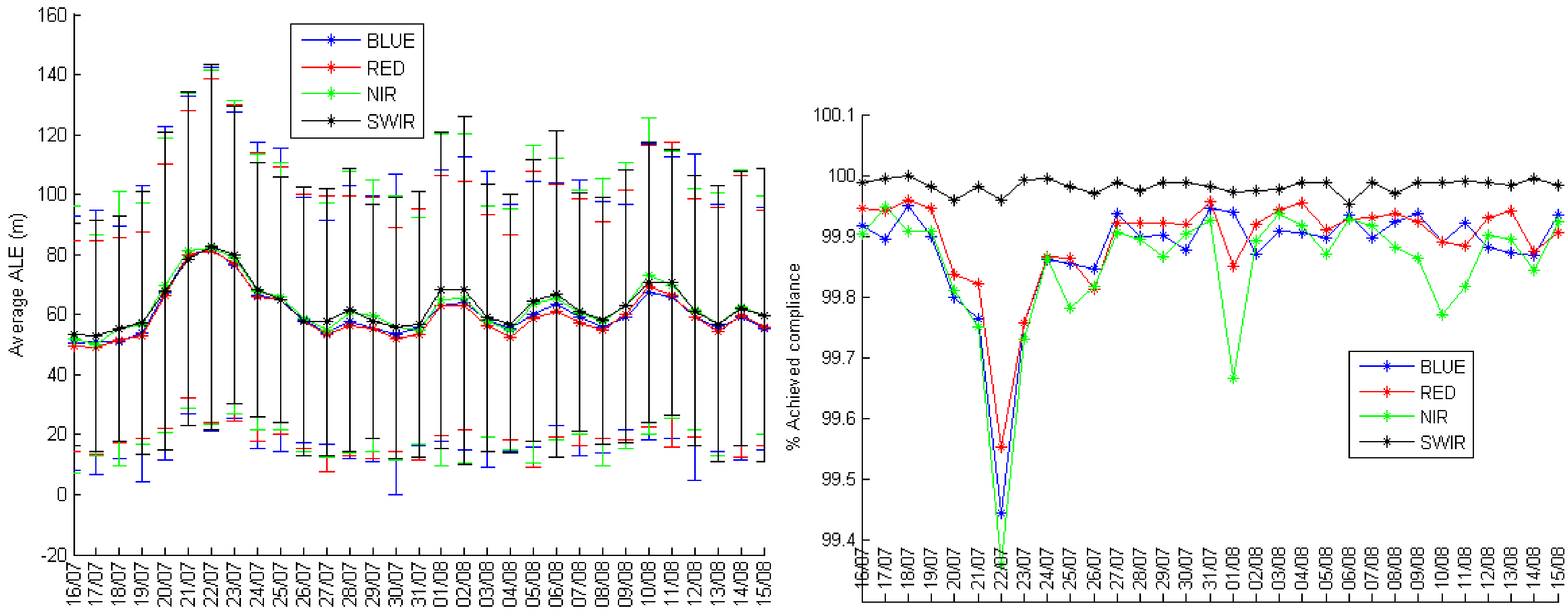
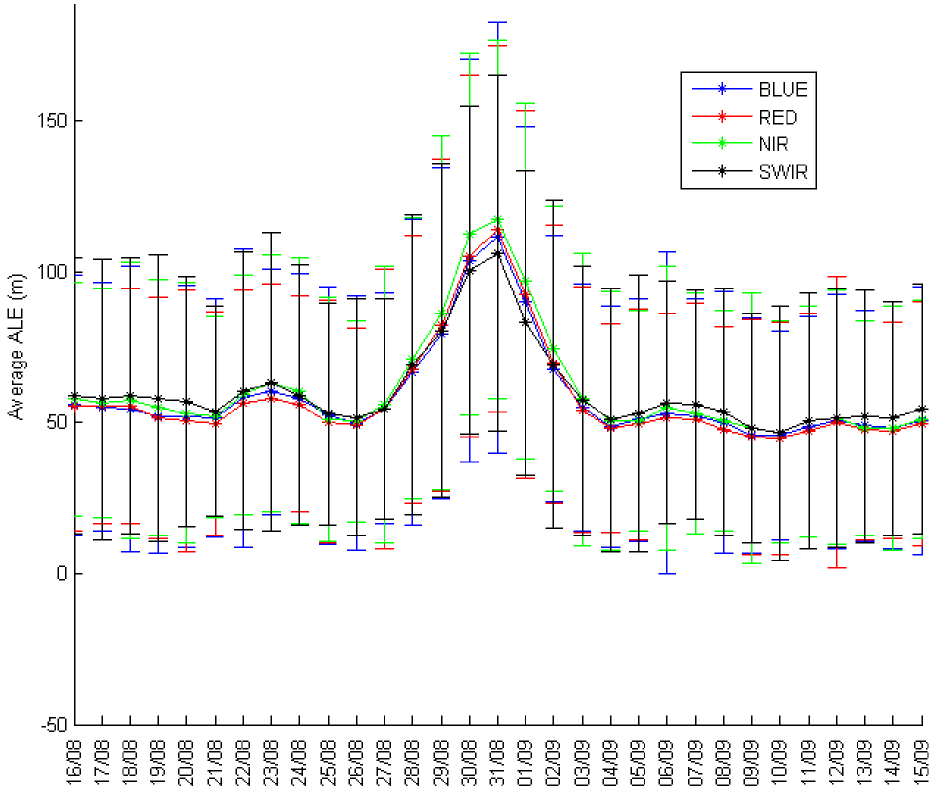


Figure 35: Daily average location error for all spectral bands in the period from 16/07/2014 to 15/08/2014 (left). The average daily compliance of the spectral bands (right).

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
16/08/2014	99.91	99.92	99.90	99.96	24374	55.82	43.04	27570	55.37	41.13	24568	57.78	38.70	19387	58.79	45.73
17/08/2014	99.92	99.93	99.95	99.97	23283	55.12	41.11	26797	55.43	38.85	23972	56.46	37.98	19156	57.78	46.64
18/08/2014	99.89	99.91	99.89	99.97	21476	54.63	47.37	24010	55.48	38.99	20589	57.59	45.72	16206	59.03	45.86
19/08/2014	99.95	99.92	99.91	99.98	19013	52.18	45.42	20918	51.50	39.91	17866	55.00	42.27	13467	58.16	47.51
20/08/2014	99.92	99.94	99.92	99.99	23796	52.19	43.25	26583	50.62	43.17	21903	53.20	43.08	16326	56.91	41.51
21/08/2014	99.94	99.96	99.94	99.99	23584	51.48	39.47	27221	49.67	37.07	23543	51.88	33.46	17679	53.79	34.91
22/08/2014	99.84	99.92	99.93	99.97	21059	58.35	49.43	23477	56.68	37.18	20932	59.27	39.76	15691	60.56	46.04
23/08/2014	99.91	99.91	99.89	99.98	25629	60.26	40.65	28354	58.13	37.61	23736	63.10	42.53	18262	63.54	49.24
24/08/2014	99.93	99.95	99.89	99.99	24693	57.83	41.75	27027	56.20	35.99	22966	60.48	44.01	17576	59.12	42.98
25/08/2014	99.92	99.94	99.95	99.98	50449	52.48	42.65	53750	50.36	40.15	49022	51.12	40.66	37588	52.87	36.94
26/08/2014	99.94	99.96	99.95	99.98	24002	49.88	42.19	26942	49.19	32.10	23250	50.43	33.38	18629	51.80	39.17
27/08/2014	99.95	99.97	99.93	99.99	24528	54.74	38.24	23558	54.55	46.27	20646	56.10	45.81	16532	54.49	36.44
28/08/2014	99.90	99.90	99.79	99.97	22841	66.71	50.67	24447	67.73	44.52	19914	71.28	46.52	15605	69.05	49.79
29/08/2014	99.75	99.63	99.25	99.98	23600	79.63	54.70	25573	82.41	55.09	22241	86.32	58.67	17979	80.53	55.46
30/08/2014	99.42	99.17	98.51	99.95	18864	103.70	66.60	20125	105.32	59.83	16695	112.42	60.02	14683	100.58	54.25
31/08/2014	99.33	99.01	98.60	99.96	17570	111.31	71.22	18371	114.18	60.48	15539	117.37	59.50	13656	106.10	58.83
1/09/2014	99.56	99.35	98.80	99.99	25297	89.91	58.28	26038	92.51	60.94	21986	96.83	58.98	15117	83.04	50.27
2/09/2014	99.91	99.89	99.72	99.97	27088	67.82	44.22	28205	69.49	46.07	23341	74.57	47.32	19853	69.24	54.42
3/09/2014	99.93	99.94	99.91	99.98	22933	54.95	40.96	24082	54.18	40.73	20516	57.74	48.52	17626	57.34	44.67
4/09/2014	99.93	99.97	99.94	99.97	23219	48.66	40.10	24831	48.07	34.57	22642	50.70	43.06	17347	51.02	43.69
5/09/2014	99.91	99.94	99.97	99.99	20789	50.92	40.23	22198	49.46	38.08	20721	50.80	36.55	14931	53.02	45.72
6/09/2014	99.90	99.94	99.90	99.99	22143	53.26	53.29	23448	51.43	34.80	21354	54.79	46.90	15316	56.53	40.24
7/09/2014	99.94	99.95	99.92	100.00	22660	52.04	38.93	24739	51.18	38.31	23618	52.95	39.95	16174	56.06	38.04
8/09/2014	99.95	99.96	99.96	99.98	24499	50.20	43.25	26096	47.92	33.73	25238	50.80	36.57	18250	53.47	40.88
9/09/2014	99.86	99.87	99.85	99.96	29971	45.79	38.89	35444	45.31	39.11	30008	48.06	44.75	31289	48.18	38.20
10/09/2014	99.82	99.84	99.84	99.92	28951	45.79	34.79	33514	44.76	38.34	28733	46.95	37.01	30080	46.54	41.97
11/09/2014	99.80	99.87	99.86	99.96	62119	48.67	36.72	70609	47.25	38.94	63708	50.41	38.38	68735	50.62	42.18
12/09/2014	99.68	99.76	99.77	99.94	32376	50.59	42.15	37379	50.23	48.33	32774	51.72	42.22	36934	51.56	43.07
13/09/2014	99.87	99.91	99.92	99.95	30380	48.95	38.34	36234	47.50	36.38	33239	48.05	35.62	35087	52.01	41.78
14/09/2014	99.84	99.87	99.86	99.96	29235	48.26	40.17	34537	47.26	35.83	33979	48.06	40.49	34198	51.49	38.66
15/09/2014	99.83	99.85	99.86	99.94	30703	50.60	44.46	34939	49.59	40.37	32697	51.05	39.43	33781	54.49	41.46
Averages	**99.84**	**99.83**	**99.75**	**99.97**	**26487.9**	**58.80**	**44.92**	**29258.6**	**58.35**	**41.70**	**25868.9**	**61.07**	**43.48**	**22359.4**	**60.57**	**44.41**

Table 11: Daily achieved compliance and the daily average location error (in m) for all spectral bands in the period 16/08/2014 to 15/09/2014.



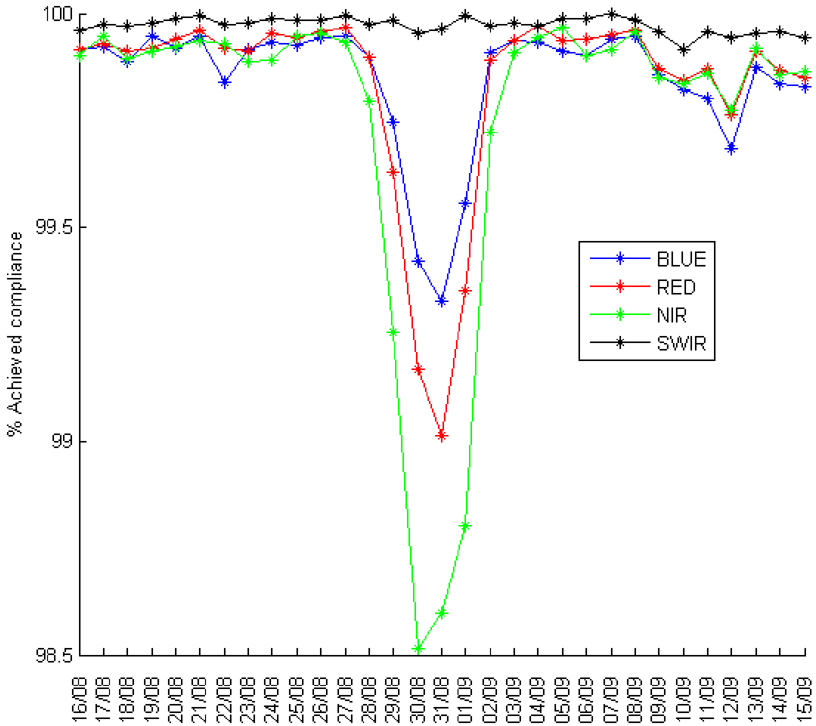


Figure 36: Daily average location error for all spectral bands in the period from 16/08/2014 to 15/09/2014 (left). The average daily compliance of the spectral bands (right).

The total number of chips per day and per spectral band used for the geometric accuracy analysis was stable (±15%) during the reporting period, except of two days (25.08.2014 and 11.09.2014), when number of chips per day was 1.9-2.3 times higher than the average. This indicates no major problem with missing segments. The total number of chips processed for this reporting increased by 34% (5459 GCPs on average) when comparing to the results reported in the previous report.

Since 09.09.2014 onwards Landsat GLS2010 is used as reference data in the geometric validation chain of PROBA-V (instead of GLS2000). An increase of 26%-40% in number of chips per day was observed for BLUE, RED and NIR strips and an increase of 90% for the SWIR strip. The impact of this reference data upgrade will be further evaluated in the next report, once more data is available.

The daily average location error compliance (ALE<300m) was at the level of 99.9%. This result is exactly as stated in previous reporting period.

The monthly average location error remained below 63m for all spectral bands (combined cameras). When comparing to the previous reporting period a 5.7% increase of the average location error was observed.
Variation in the average location error is relatively small (1σ standard deviation < 47m) and correlated for all spectral bands (similar trends can be observed in the left part of Figure 34, Figure 35 and Figure 36). This indicates that the geometric inter-band error between the spectral bands is stable and low (see section below).

Lower geometric quality performance was observed between 28.08.2014 and 02.09.2014, when the average daily location error increased to 117m (1σ standard deviation < 60m). The source of this temporal geometric deterioration is unknown. Analysis of the telemetry data by ESA and QinetiQ did not bring any cues. Since 03.09.2014 onwards the geometric Proba-V performance is back to average.

A decrease of 18% (in comparison to the 3 months average ALE) in the average location error is observed after the upgrade of the reference data (09.09.2014) to Landsat GLS2010. The impact of the reference data upgrade on the ALE will be further evaluated in the next report, once more data is available.

2.3.2. Inter-band geometric accuracy

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

Band pair	Inter-band error [m]
BLUE-RED	27.0, std=6.7
BLUE-NIR	41.6, std=11.7
BLUE-SWIR	42.0, std=10.9
RED-NIR	28.9, std=10.8
RED-SWIR	34.2, std=8.9
NIR-SWIR	38.0, std=10.4

Table 12: Inter-band geolocation accuracy for period 16/06/2014 to 15/07/2014 stated for combined cameras, at 95% confidence level.

Band pair	Inter-band error [m]
BLUE-RED	27.3, std=6.6
BLUE-NIR	44.0, std=14.4
BLUE-SWIR	42.8, std=14.6
RED-NIR	30.4, std=12.0
RED-SWIR	32.9, std=8.5
NIR-SWIR	38.4, std=11.6

Table 13: Inter-band geolocation accuracy for period 16/07/2014 to 15/08/2014 stated for combined cameras, at 95% confidence level.

Band pair	Inter-band error [m]
BLUE-RED	27.2, std=7.0
BLUE-NIR	45.8, std=18.4
BLUE-SWIR	42.0, std=10.3
RED-NIR	40.7, std=9.9
RED-SWIR	32.5, std=8.1
NIR-SWIR	37.3, std=11.5

Table 14: Inter-band geolocation accuracy for period 16/08/2014 to 15/09/2014 stated for combined cameras, at 95% confidence level.

For combined cameras the inter-band geometric accuracy remained stable and ranged from 27 m to 46 m (std ~= 11 m), that is 0.08 – 0.14 of a pixel (333m). This result is comparable (on average 2% worse) to the result reported in the previous reporting period (16/03/2013 – 15/06/2014) with an exception of the RED-NIR inter-band geolocation error in the last reporting month. The 19% increase of the RED-NIR inter-band geolocation error (to 40.7m or 0.12pix, see Table 14) in the period 16/08/2014 to 15/09/2014 is strongly related to the temporal Proba-V geometric performance deterioration between 28.08.2014 and 02.09.2014 (see Figure 36 left).
Exclusion of this week from the statistics for 16/08/2014 to 15/09/2014 leads to the RED-NIR inter-band geolocation error at the level of 30.5m (0.09pix), that is 1% higher than the average value reported in the previous report.

The inter-band NIR-SWIR registration accuracy is at the level of 38 m (0.5% higher than in the previous report).

2.3.3. Multi-temporal geometric accuracy

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

- 95.4% for the VNIR sensor (123835 GCPs used),

- 99.3% for the VNIR/SWIR combined (132864 GCPs used).

This compliance level is comparable to the previous reporting period (95.7% for the VNIR sensor and 99.5% for the VNIR/SWIR combined).

Due to the very high impact of the startracker patch on the geometric data performance, the overall multi-temporal geometric accuracy was evaluated only for the last two reporting periods (16.03.2014-15.09.2014) and is as follows:

- 95.2% for the VNIR sensor (147451 GCPs used),
- 99.3% for the VNIR/SWIR combined (157414 GCPs used).

2.4. Geometric ICP file

The geometric ICP file created on the 24th of March (after the startracker patch was applied) was valid for the entire reporting period and to date the no updates are foreseen.

ICP filename	Description
PROBAV_ICP_GEOMETRIC#LEFT_20140312_V01 PROBAV_ICP_GEOMETRIC#CENTER_20140312_V01 PROBAV_ICP_GEOMETRIC#RIGHT_20140312_V01	Update after startracker patch

Table 15: Geometric ICP-file updates

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 16: Reference Documents