proba-v

QUARTERLY IMAGE QUALITY REPORT

IQR#034

Reporting period from 16/06/2022 to 15/09/2022

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TABLE OF CONTENT

TABLE OF FIGURES

1. Introduction

For the next phase in its lifetime, PROBA-V will acquire only a limited number of segments, for accommodating instrument sanity, while it is in a hibernate condition. The instrument is kept in stand-by for reasons the thermal stability.
A limit number of calibration images will be acquired to monitor both radiometric and geometric sanity of the instrument. The acquisitions will serve both methods 'at once' as much as possible.

1.1. Calibration Plan - 'hibernate'

For radiometry it is decided that lunar measurements over the full cycle will be continued every month. As an addition to this, few dark current (DC) acquisitions will be done to allow for the automated monitoring of the dark signal and bad pixel detection. The DC will be acquired for all 3 cameras. The amount of calibrations in a month will be 19 lunar and 2 DC resulting in < 1GByte in data.

2 extra acquisitions for Railroad Valley are programmed every month.

Figure 1: Railroad Valley area

Figure 2: Close-up of the site

1.2. Calibration Requests

Currently the following planning (Table 2) has been executed or waiting to be executed on board. In the IQC database, 101 calibration products have been stored out of 130 planned requests. Only 2 of these failures are rejected on board, the others failed somewhere in the data chain, at TFF or at L1A level.

Update last period from 16/06/2022 upto 20/09/2022 (data only retrieved from MCC until 20/09/2022)

- About 95 calibration requests have been submitted
- acquisitions per method
  - DARK CURRENT : 11
  - RADCALNET :
    - RAILROAD : 12
    - GOBABEB : 13
  - MOON : 57
- 81 LEVEL 1A files at DIF (others are 'planned' or failed)
- L1B products in IQC DB : 77
  - DC : 30 (3 cameras)
  - RADCALNET : 8
  - MOON : 39

Once a month, around start of a new moon cycle, the full planning is programmed : moon, DARKCURRENT and Railroad Valley are inserted into the IPC and uploaded to the platform.

Table 1 : List of planned and executed calibration acquisitions

#	CAMERA	DATE	REGION OF INTEREST	TYPE	STATUS
1	CENTER	05/07/2022 15:30	RailRoad_Valley_2	MISCELLANEOUS	EXECUTED
2	CENTER	06/07/2022 16:09	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
3	CENTER	07/07/2022 03:50	DC_PSE_001_02s_2_2_2_2	DARK_CURRENT	EXECUTED
4	CENTER	07/07/2022 12:24	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
5	CENTER	08/07/2022 23:50	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
6	CENTER	09/07/2022 05:51	Gobabeb	MISCELLANEOUS	EXECUTED
7	CENTER	09/07/2022 18:24	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
8	CENTER	10/07/2022 11:16	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
9	CENTER	10/07/2022 15:18	RailRoad_Valley_2	MISCELLANEOUS	EXECUTED
10	CENTER	11/07/2022 04:09	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
11	CENTER	11/07/2022 21:01	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
12	CENTER	12/07/2022 10:31	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
13	CENTER	12/07/2022 17:16	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
14	CENTER	13/07/2022 06:02	Gobabeb	MISCELLANEOUS	EXECUTED
15	CENTER	13/07/2022 15:13	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
16	CENTER	14/07/2022 01:20	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
17	CENTER	14/07/2022 16:31	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
18	CENTER	16/07/2022 03:50	DC_PSE_001_02s_2_2_2_2	DARK_CURRENT	EXECUTED
19	CENTER	18/07/2022 05:51	Gobabeb	MISCELLANEOUS	EXECUTED
20	CENTER	18/07/2022 11:39	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
21	CENTER	18/07/2022 15:01	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
22	CENTER	19/07/2022 15:18	RailRoad_Valley_2	MISCELLANEOUS	EXECUTED
23	CENTER	20/07/2022 04:09	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
24	CENTER	21/07/2022 00:24	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
25	CENTER	22/07/2022 03:16	DC_PSE_001_02s_2_2_2_2	DARK_CURRENT	EXECUTED
26	CENTER	22/07/2022 06:02	Gobabeb	MISCELLANEOUS	EXECUTED
27	CENTER	03/08/2022 03:49	DC_PSE_001_02s_2_2_2_2	DARK_CURRENT	EXECUTED
28	CENTER	05/08/2022 01:31	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
29	CENTER	05/08/2022 05:51	Gobabeb	MISCELLANEOUS	EXECUTED
30	CENTER	05/08/2022 20:05	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
31	CENTER	06/08/2022 15:18	RailRoad_Valley	MISCELLANEOUS	EXECUTED
32	CENTER	07/08/2022 07:31	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
33	CENTER	07/08/2022 15:57	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
34	CENTER	08/08/2022 08:50	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED

35	CENTER	09/08/2022 10:09	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
36	CENTER	09/08/2022 15:12	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
37	CENTER	10/08/2022 06:24	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
38	CENTER	11/08/2022 00:57	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
39	CENTER	11/08/2022 11:05	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
40	CENTER	12/08/2022 00:35	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
41	CENTER	13/08/2022 00:12	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
42	CENTER	13/08/2022 20:27	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
43	CENTER	14/08/2022 03:04	DC_PSE_001_02s_2_2_2_2	DARK_CURRENT	EXECUTED
44	CENTER	14/08/2022 05:51	Gobabeb	MISCELLANEOUS	EXECUTED
45	CENTER	15/08/2022 09:35	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
46	CENTER	15/08/2022 15:18	RailRoad_Valley	MISCELLANEOUS	EXECUTED
47	CENTER	16/08/2022 04:09	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
48	CENTER	16/08/2022 22:42	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
49	CENTER	17/08/2022 20:39	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
50	CENTER	18/08/2022 16:54	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
51	CENTER	19/08/2022 02:53	DC_PSE_001_02s_2_2_2_2	DARK_CURRENT	EXECUTED
52	CENTER	19/08/2022 13:09	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
53	CENTER	20/08/2022 15:07	RailRoad_Valley	MISCELLANEOUS	EXECUTED
54	CENTER	21/08/2022 05:39	MOON_001_06_2_2_2_2_2_2	MOON	REJECTED
55	CENTER	21/08/2022 15:46	MOON_001_06_2_2_2_2_2_2	MOON	REJECTED
56	CENTER	22/08/2022 06:57	MOON_001_06_2_2_2_2_2_2	MOON	REJECTED
57	CENTER	22/08/2022 17:05	MOON_001_06_2_2_2_2_2_2	MOON	REJECTED
58	CENTER	23/08/2022 05:51	Gobabeb	MISCELLANEOUS	EXECUTED
59	CENTER	24/08/2022 15:18	RailRoad_Valley	MISCELLANEOUS	EXECUTED
60	CENTER	28/08/2022 05:39	Gobabeb	MISCELLANEOUS	EXECUTED
61	CENTER	29/08/2022 15:07	RailRoad_Valley	MISCELLANEOUS	EXECUTED
62	CENTER	31/08/2022 18:46	MOON_001_06_2_2_2_2_2_2	MOON	REJECTED
63	CENTER	01/09/2022 03:04	DC_PSE_001_02s_2_2_2_2	DARK_CURRENT	EXECUTED
64	CENTER	01/09/2022 05:50	Gobabeb	MISCELLANEOUS	EXECUTED
65	CENTER	01/09/2022 06:35	MOON_001_06_2_2_2_2_2_2	MOON	REJECTED
66	CENTER	01/09/2022 16:42	MOON_001_06_2_2_2_2_2_2	MOON	REJECTED
67	CENTER	02/09/2022 06:12	MOON_001_06_2_2_2_2_2_2	MOON	REJECTED
68	CENTER	02/09/2022 15:18	RailRoad_Valley	MISCELLANEOUS	EXECUTED
69	CENTER	02/09/2022 16:20	MOON_001_06_2_2_2_2_2_2	MOON	REJECTED
70	CENTER	03/09/2022 05:50	MOON_001_06_2_2_2_2_2_2	MOON	REJECTED
71	CENTER	03/09/2022 15:57	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
72	CENTER	07/09/2022 02:38	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
73	CENTER	07/09/2022 05:17	Gobabeb	MISCELLANEOUS	EXECUTED
74	CENTER	07/09/2022 15:07	RailRoad_Valley_2	MISCELLANEOUS	EXECUTED

75	CENTER	07/09/2022 19:31	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
76	CENTER	08/09/2022 14:05	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
77	CENTER	09/09/2022 03:27	DC_PSE_001_02s_2_2_2_2	DARK_CURRENT	EXECUTED
78	CENTER	09/09/2022 08:38	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
79	CENTER	09/09/2022 23:50	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
80	CENTER	10/09/2022 05:50	Gobabeb	MISCELLANEOUS	EXECUTED
81	CENTER	11/09/2022 09:35	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
82	CENTER	11/09/2022 15:18	RailRoad_Valley_2	MISCELLANEOUS	EXECUTED
83	CENTER	12/09/2022 04:08	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
84	CENTER	13/09/2022 00:23	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
85	CENTER	13/09/2022 03:38	DC_PSE_001_02s_2_2_2_2	DARK_CURRENT	EXECUTED
86	CENTER	13/09/2022 07:08	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
87	CENTER	13/09/2022 22:20	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
88	CENTER	15/09/2022 05:39	Gobabeb	MISCELLANEOUS	EXECUTED
89	CENTER	15/09/2022 18:12	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
90	CENTER	16/09/2022 02:31	DC_PSE_001_02s_2_2_2_2	DARK_CURRENT	EXECUTED
91	CENTER	16/09/2022 12:46	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
92	CENTER	16/09/2022 15:06	RailRoad_Valley_2	MISCELLANEOUS	EXECUTED
93	CENTER	17/09/2022 10:42	MOON_001_06_2_2_2_2_2_2	MOON	EXECUTED
94	CENTER	18/09/2022 03:26	DC_PSE_001_02s_2_2_2_2	DARK_CURRENT	EXECUTED
95	CENTER	19/09/2022 05:50	Gobabeb	MISCELLANEOUS	EXECUTED

Table 2 : List of planned and executed calibration acquisitions

2. Radiometric image quality

2.1. Current issues : update required

Due to limitation of the S-band download capacity, 3 types of calibration are performed :

- MOON
- DARK CURRENT
- RADCALNET
    - Railroad valley
    - Gobabeb

Only 2 DARK CURRENT and 2 Railroad Valley. In the last lunar calibration campaign, we notice that, due to the lack of updating the calibration, the current parameters are no longer valid. In practice, this means that a majority of the pixels are becoming invalid due to negative radiance, after application of the sensor model. Therefore, an update of the Dark Current and Absolute Calibration parameters for both VNIR and SWIR is now inevitable.

2.2. Moon acquisitions

Due to the lack of updates to the Radiometric calibration, images of the moon are no longer automatically processed to the final calibration results. This requires a manual intervention and blocks some results from being processed. The entire database with lunar acquisitions will be processed using the most recent calibration parameters for the appropriate period.

Trending analysis up to June 2022 shows that there are currently no major issues

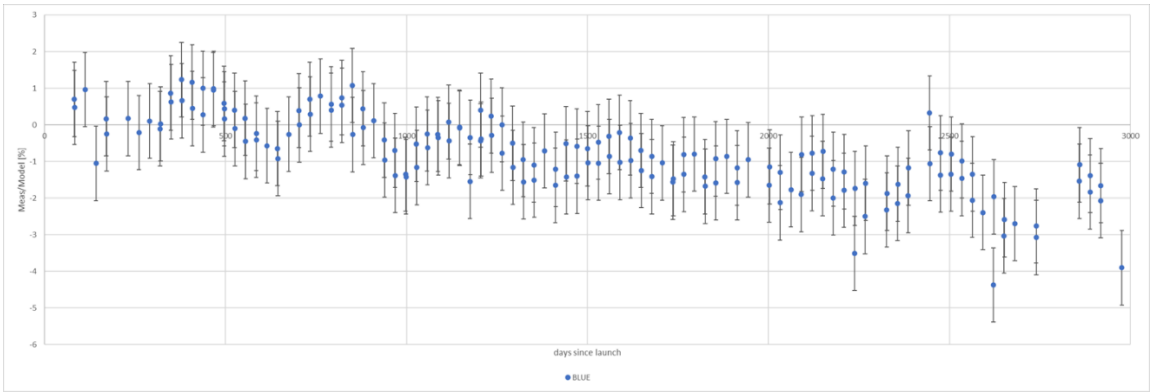

Figure 3 : Absolute Calibration trend for the BLUE channel

The processed lunar acquisitions already reveal interesting information about the PROBA-V to LIME comparison (Figure 4).

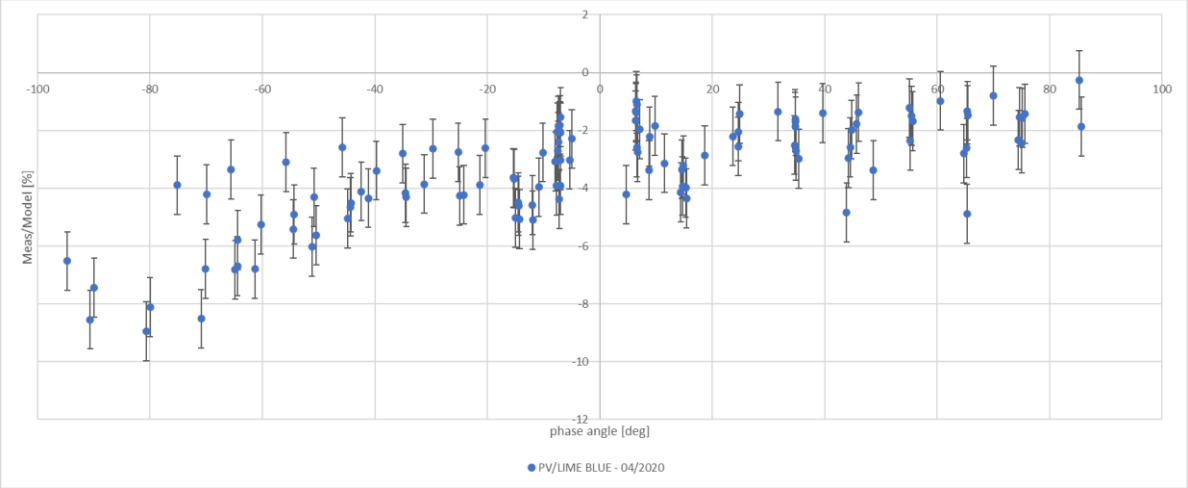

Figure 4: PROBAV to LIME comparison, revealing phase dependencies

2.3. Dark Current

The update of the dark current requires enough acquisitions to have statistical relevant update. Therefore, an assessment is done if the dark section of the lunar acquisitions can be used to do this update. Based upon the DN values you can see values for the SWIR2 (Figure 6) both cases of normal DC and Moon DARK are already quite close, but for the BLUE (VNIR) the DN values are 5x larger. This is related to the Integration Time of the instrument, but it also might mean that we cannot update the VNIR with these acquisitions.

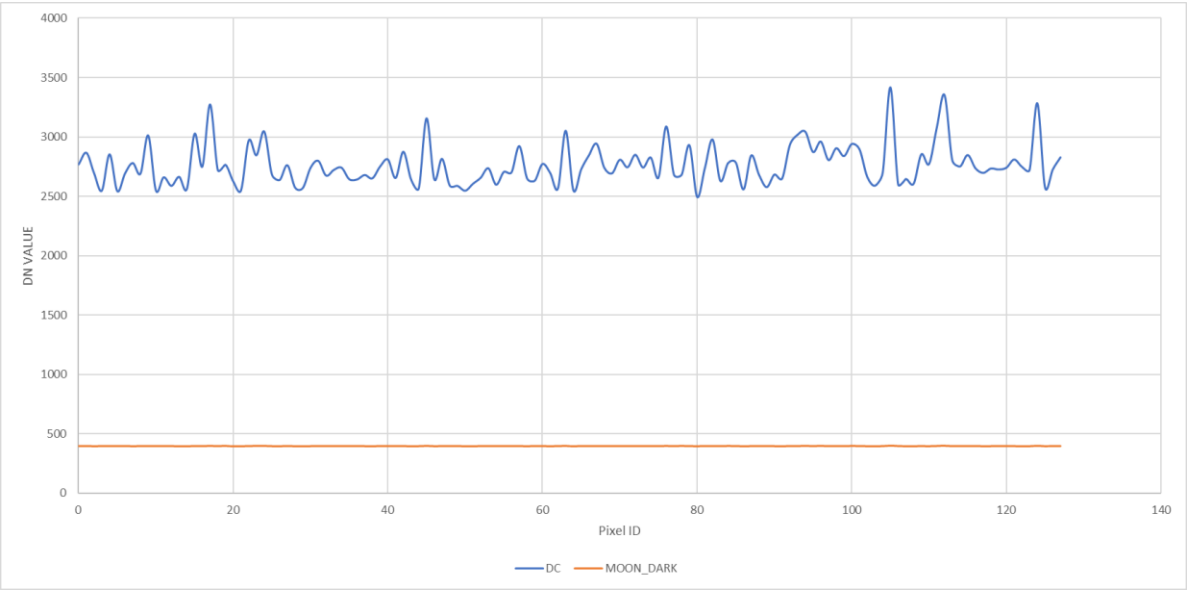

Figure 5: BLUE DC and MOON DARK DN values

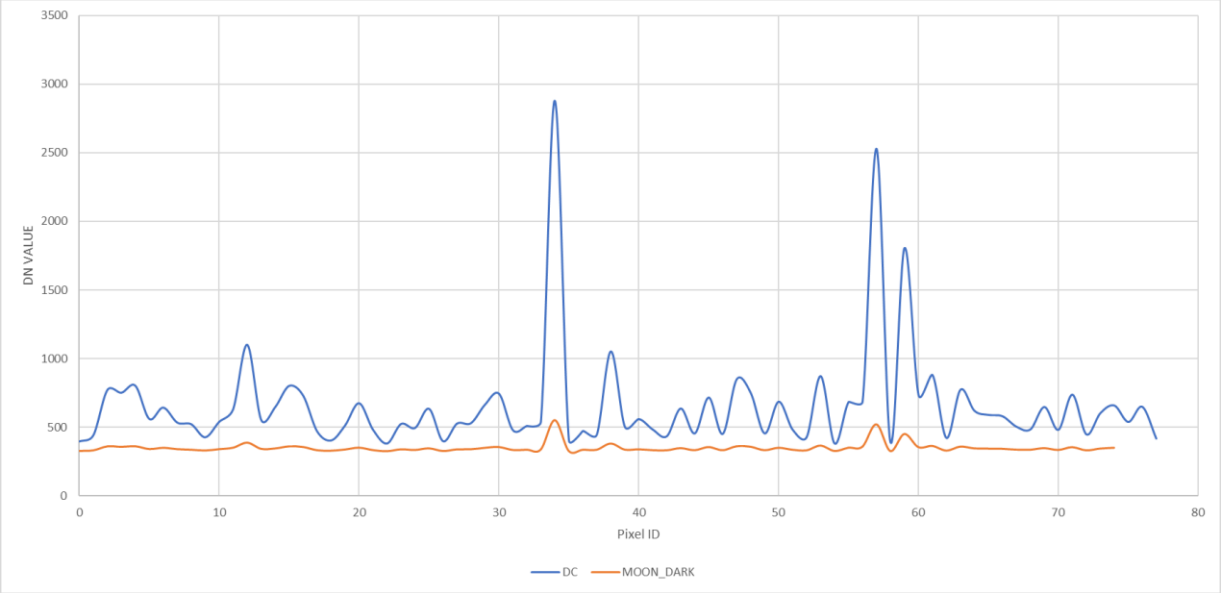

Figure 6: SWIR2 DC and MOON DARK DN values

The major cause of the Dark current increases is related to temperature and sensor ageing. Updates have not been done up to now due to lack of measurements. In the current period, many more

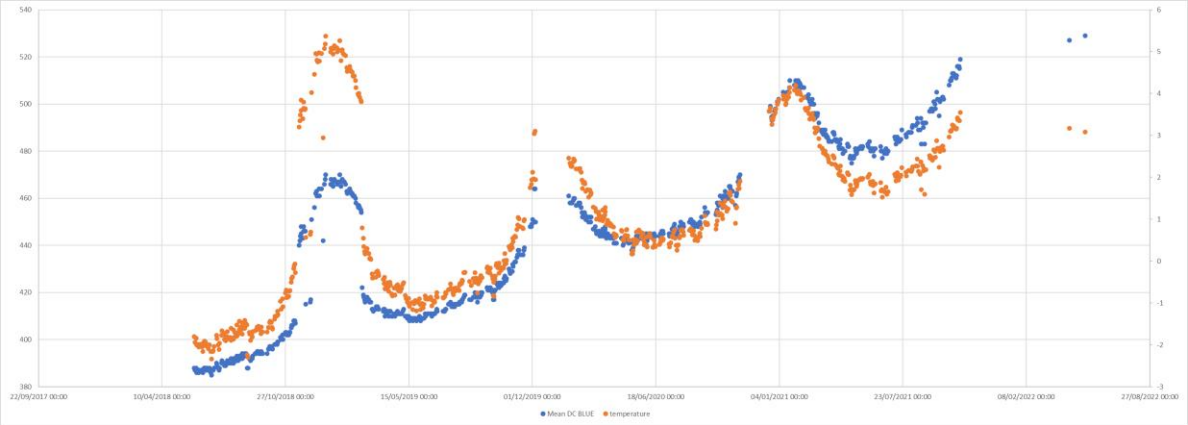

Figure 7: Temperature dependent Dark Current evolution (temperature in orange, DC in BLUE)

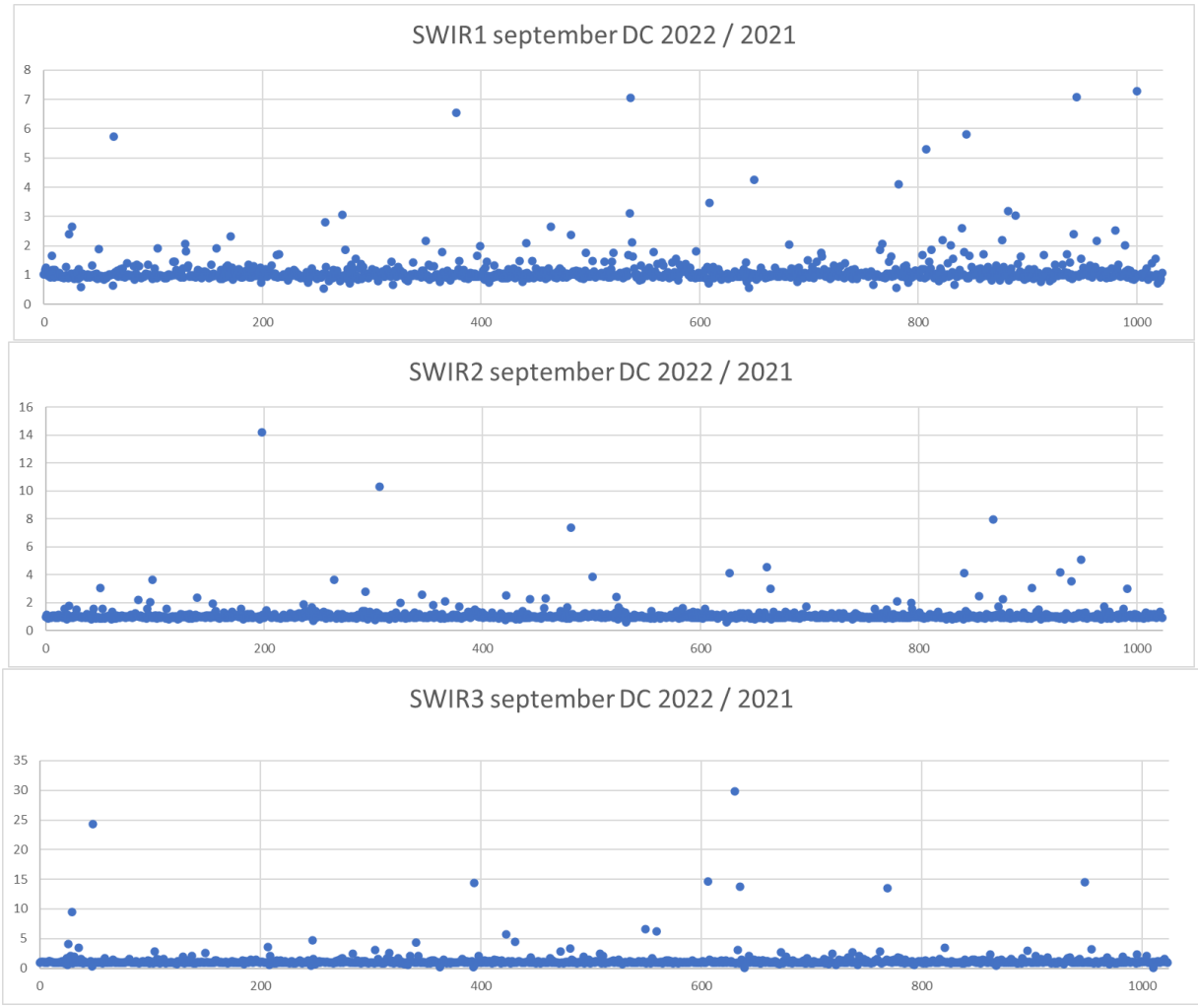

Figure 8 : increase in DC levels for a)SWIR1, b)SWIR2 and c)SWIR3

After one year, a limited assessment was performed to reveil the increase in Dark Current values for the 3 CENTER SWIR strips, as an indication to the increase of bad pixels. A limited amount of DC measurements was conducted. In Figure 8 the DC ratio between September 2022 and 2021 values are plotted for all detectors. SWIR 1 shows more increased pixel levels between the 2 timestamps (09/2021 – 09/2022) than CENTER SWIR2 ans 3.

On average the DC level has increase with the exected overall level (Figure 9) .

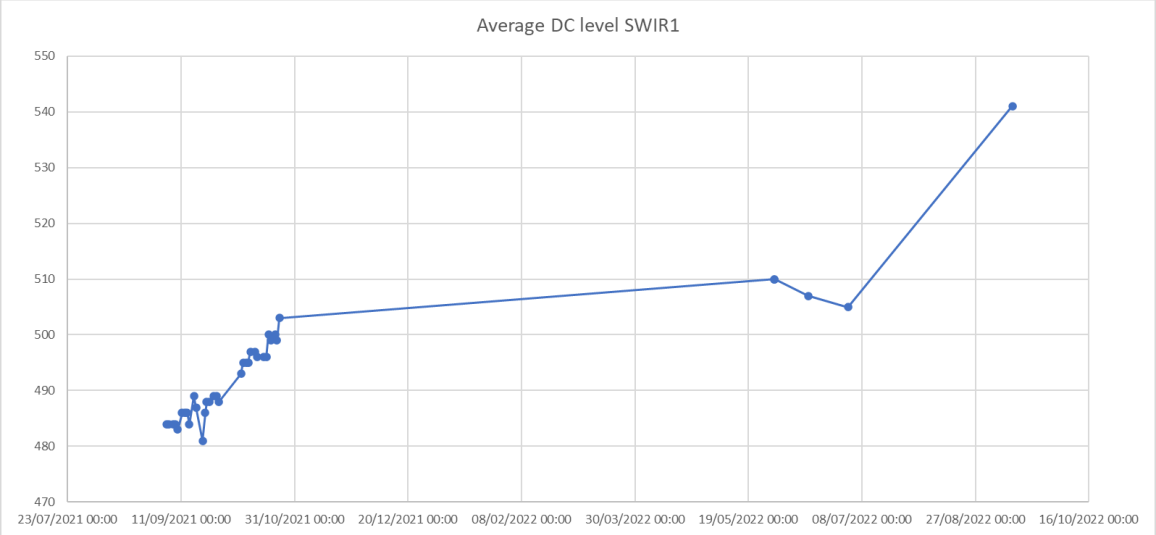

Figure 9: Average Dark Current level for CENTER SWIR1

No specific deviations from normal detected.

2.4. Railroad Valley

From the current only one image of railroad valley was processed up to L1B format. Acquisition taken at 10/02/2022 – 16.30 UTC. Figure 10 shows the unprojected quick look of the BLUE band.

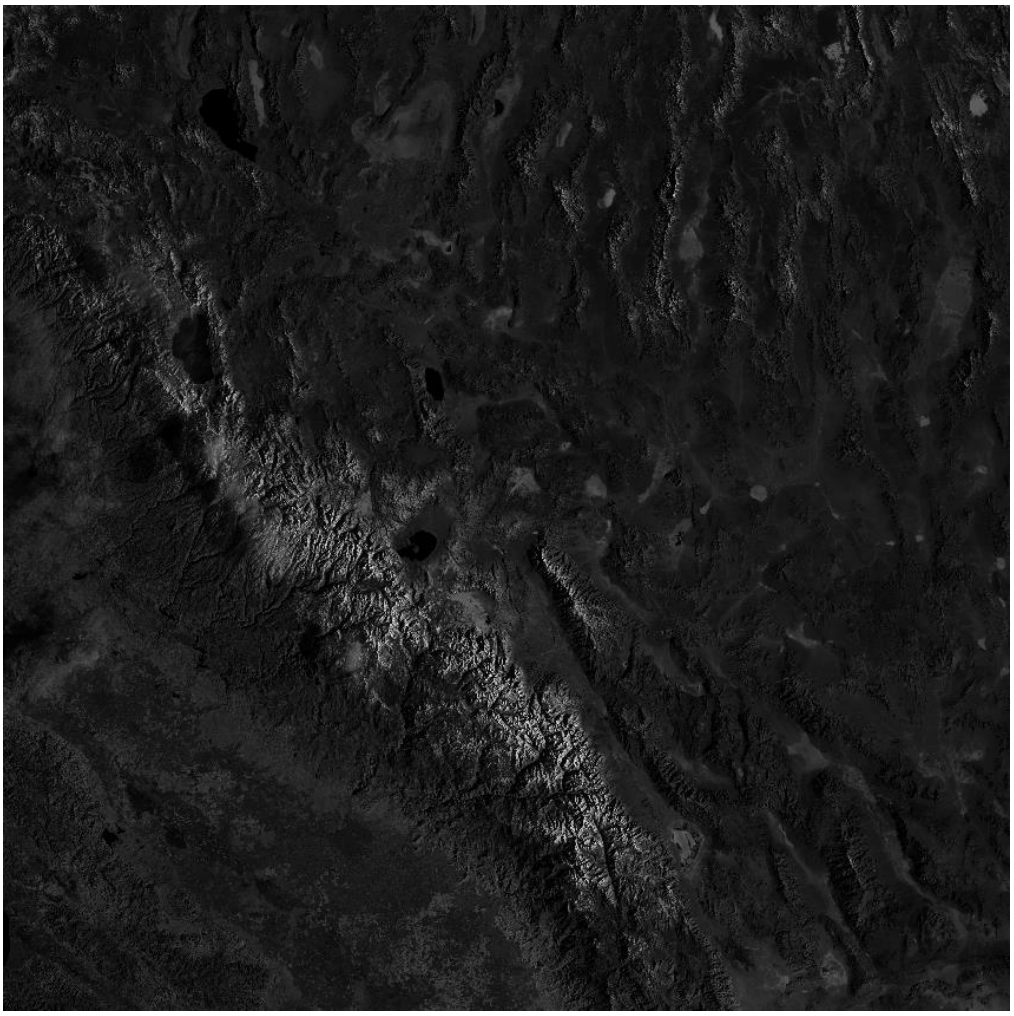

Figure 10: PROBA-V BLUE Railroad Valley acquisition 10/02/2022

When inspecting the retrieved data, the DN values appear to be extremely low. Two main reasons have been identified :

- Instrument Integration Time settings.

Since there is are longer nominal data acquisitions, the data is recorded with IPC. When creating the new calibration plan for Railroad Valley, instrument settings were recovered from another calibration opportunity with IT=1.2ms. With nominal acquisitions (i.e. for Libya4) the IT = 3ms

- Local Time Solar Zenith angle.

At the time of the image, the solar elevation angle approx. 25 degrees, which is quite low.

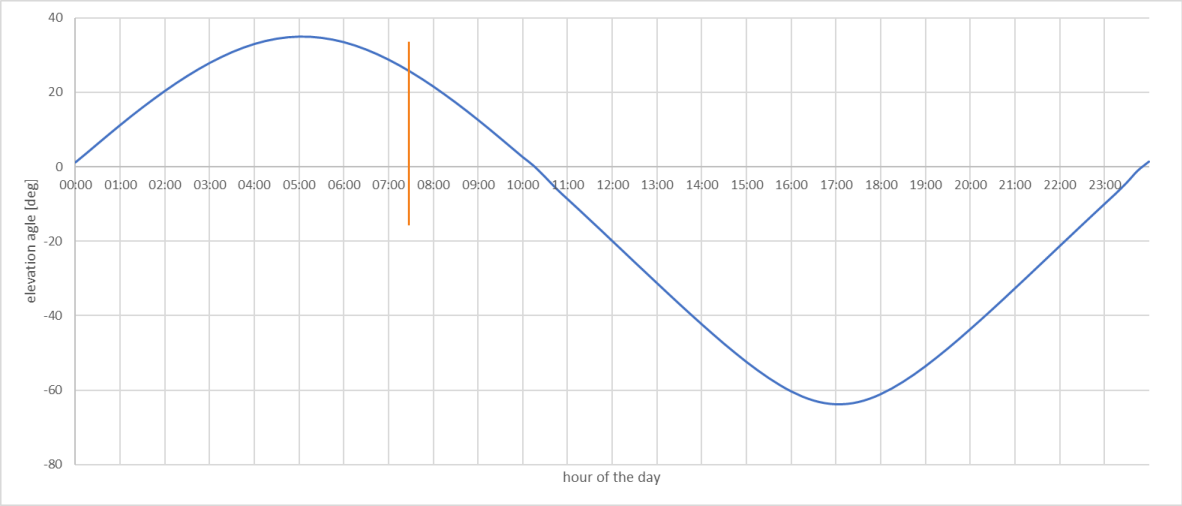

Figure 11: Solar Elevation angle at Railroad valley for 10/02/2022

In Figure 7 the TOA reflectance level, provided through RADCALNET, is plotted for the timestamp closest to the PROBA-V overpass. These numbers are based on direct reflectance and atmospheric measurements which are fed into a Radiative Transfer Model to calculate the TOA reflectance. The TOA reflectance levels are comparable to desert reflectances.

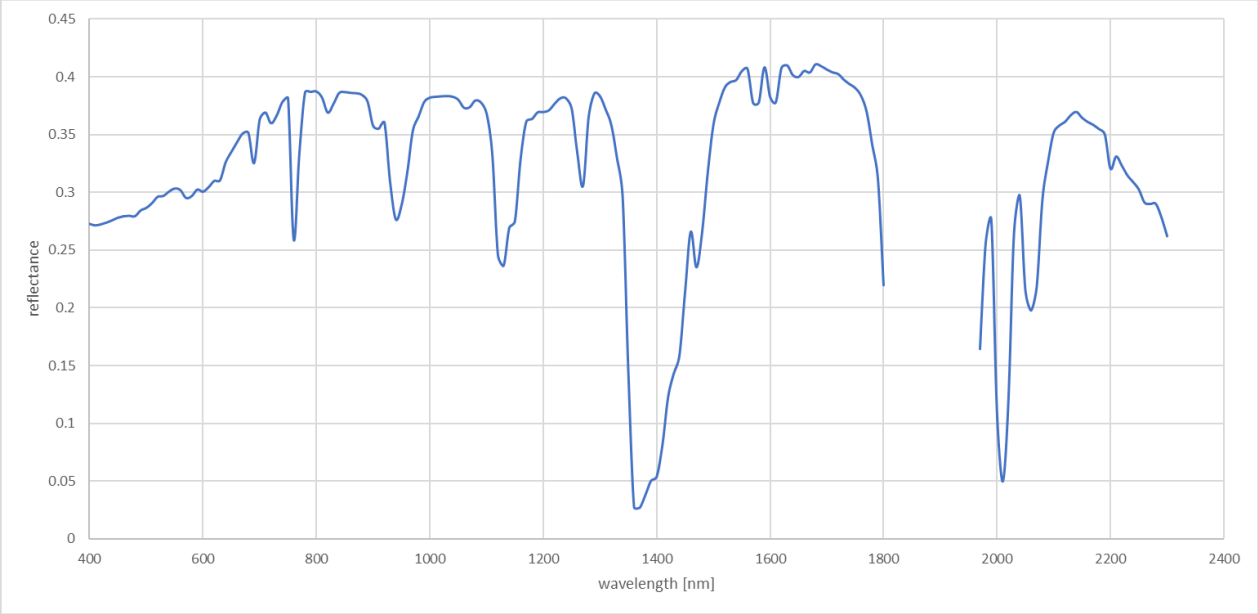

Figure 12: Railroad Valley TOA Reflectance for the closest measurement timestamp (17.00h UTC)

The first result from acquisitions with PROBA-V, taken at 15/04/2022 is shown in the next two plots. As you can see from the image, the integration time was increased, which resulted in a useful DN range. The BLUE band still has problems, due to the lacking DC updates.

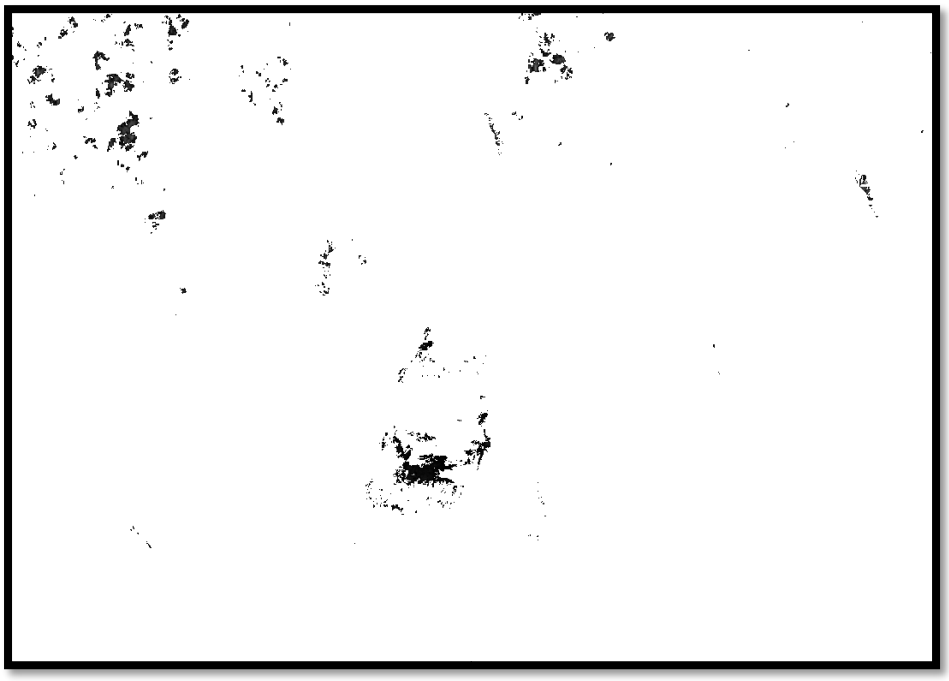

Figure 13: BLUE saturated image of Railroad Valley

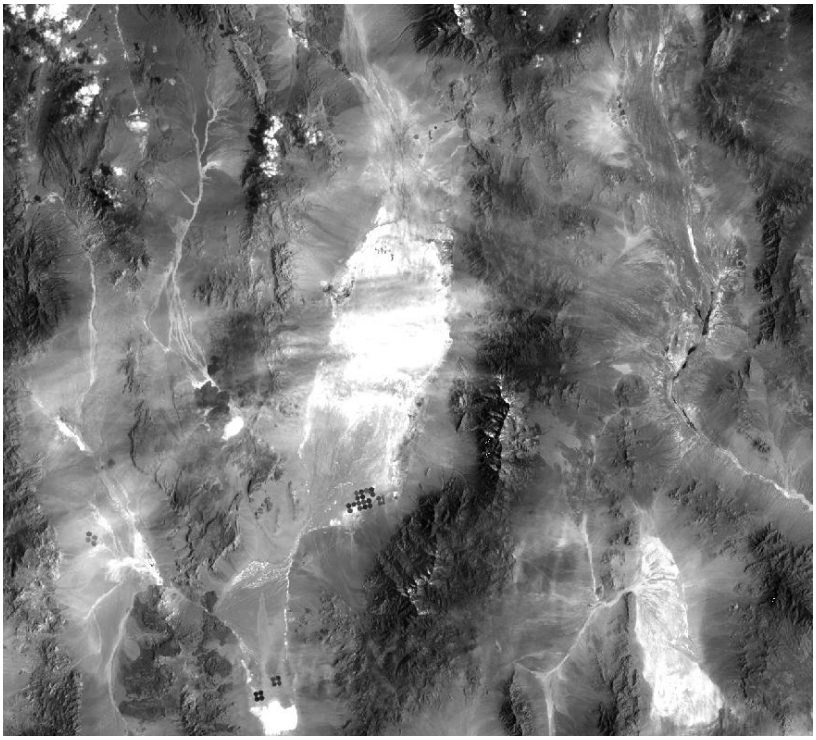

Figure 14: PROBA-V Image Railroad valley 15/04/2022

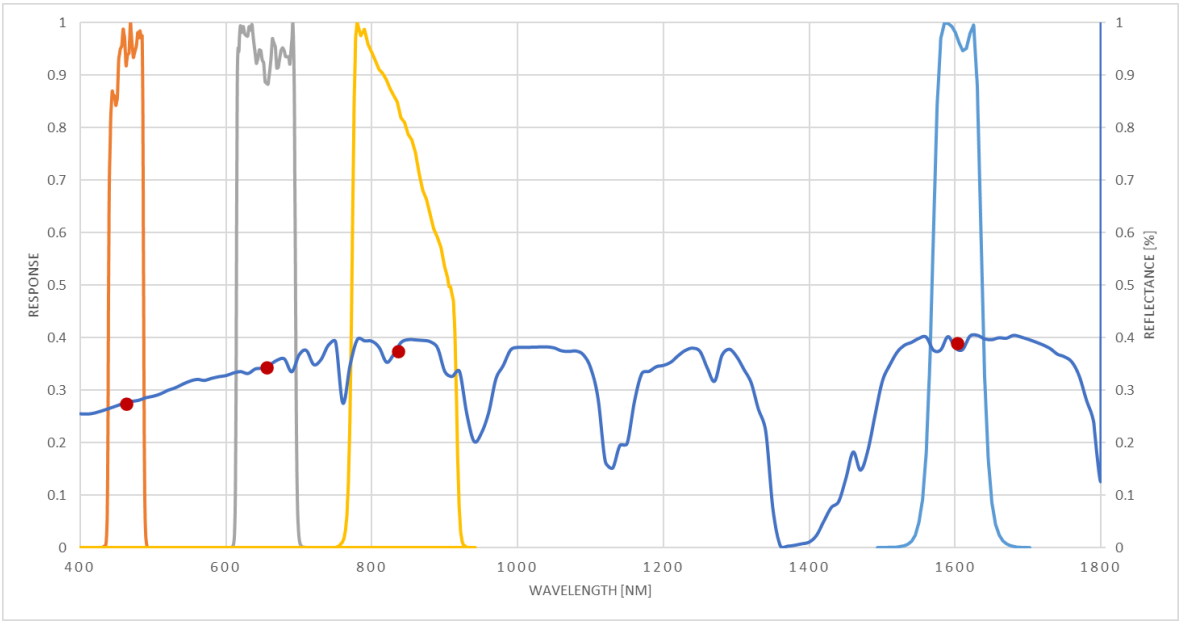

Figure 15 : Railroad Valley TOA reflectance (red points are convolved values with PV SRF)

First result shows very good agreement between PROBA-V and Railroad Valley data. For the BLUE band no values are found due to possible under correction of DC, introducing saturated values in the image (TBD). Green dots in the curve show that PROBA-V is in absolute terms still in line with the requirements of 5%.

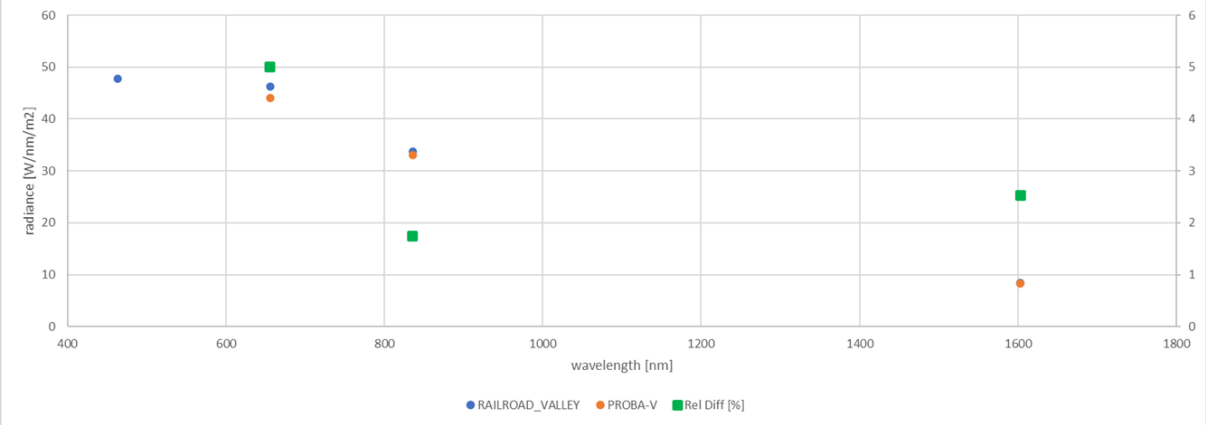

Figure 16: Result from the PROBA-V - Railroad valley comparison

2.5. Gobabeb

In the period from 1st of July onwards, a second RadCalNet calibration site "Gobabeb" was introduced into increase the amount of calibration references (both for radiometry and geometry). Near the 'Gobabeb training centre' a site was put up with instruments (comparable to Raylroad Valley) providing operationally hyperspectral BOA and TOA reflectance values.

Figure 17: Gobabeb RadCalNet site in Namib desert

Unfortunately, due to some error in the IPC (wrong input provided by calibration opertator), the ROI of RailRoad Valley has been submitted in stead of the Gobabeb. This is now corrected for the next period and correct data will beretrieved for Gobabeb.
The data was processed upto L1A. therefor no full comparon has been undertaken at this moment.

Figure 18: Unprojected PROBA-V DN image of the Gobabeb area for 18/07/2022

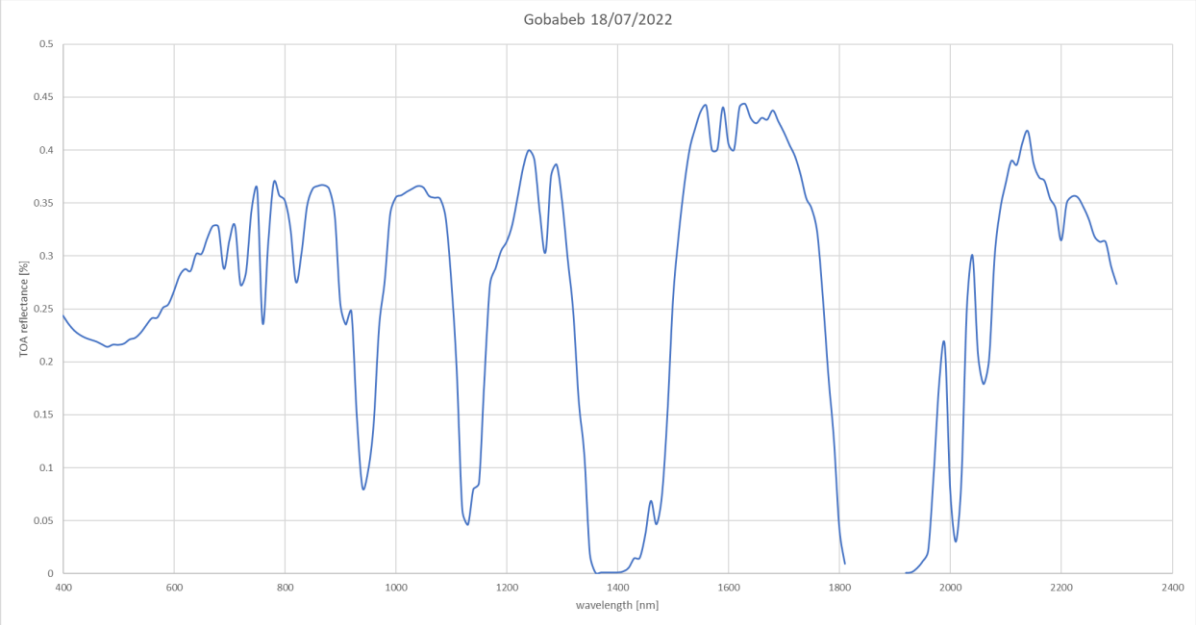

Figure 19: GOBABEB TOA Reflectance for the closest measurement timestamp (09.00h UTC)

A full analysis of RailRoad and Gobabeb will be added in the next report.

3. Geomatric image quality

The geometric performance is measured on both ROIs (Railroad Valley site and Gobabeb site).

For every acquisition, we measure:
- Along track distortion vs detector position in the sensor geometry (in pixels)
- Across track distortion vs detector position in the sensor geometry (in pixels)
- Along track distortion vs Across track distortion (in pixels)

3.1. Railroad Valley

PROBAV_L1A_20220210_163205_2_V101

The table below shows the geometric statistics:

Band	Mean across distortion (pixel)	Mean along distortion (pixel)	Number of GCPs
BLUE	0.49122	0.64674	899
NIR	0.50761	0.58115	1035
RED	0.50736	0.60418	942
SWIR1	0.36518	0.41804	71
SWIR2	0.44193	0.44666	67
SWIR3	0.67144	0.47281	27

Table 3: geometric statisctics of segment PROBAV_L1A_20220210_163205_2_V101

The figure below shows the distortions plots (across, along track) for all spectral bands.

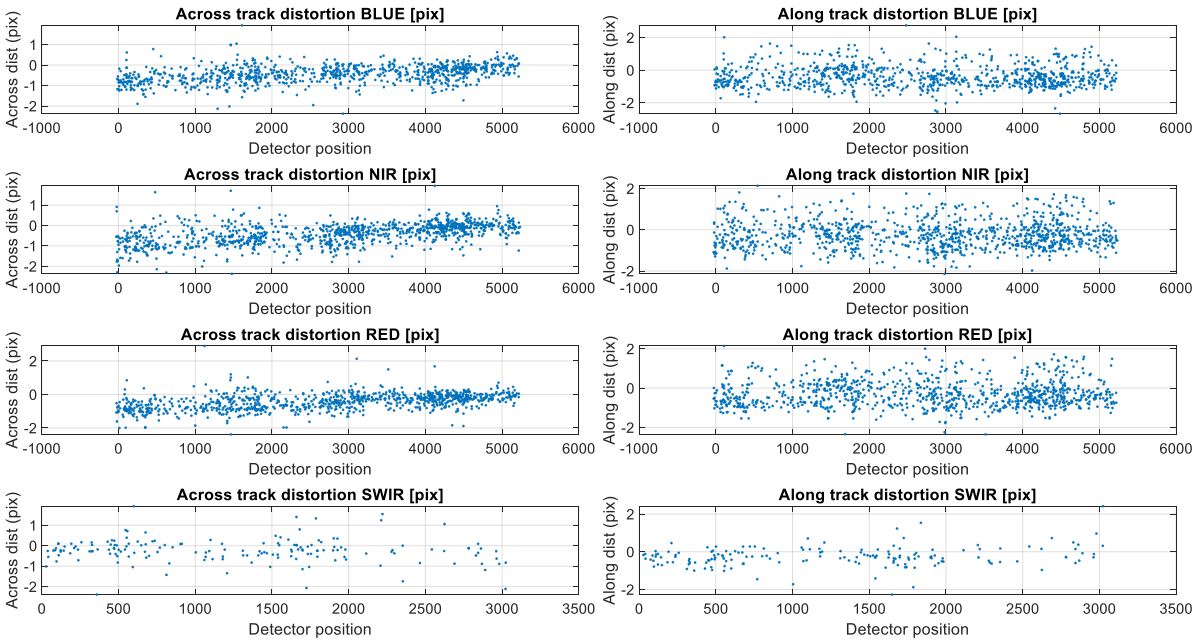

Figure 20: Distortion plots of PROBAV_L1A_20220210_163205_2_V101

The figure below shows the along track distortion in function of the across track distortion in pixels for all spectral bands.

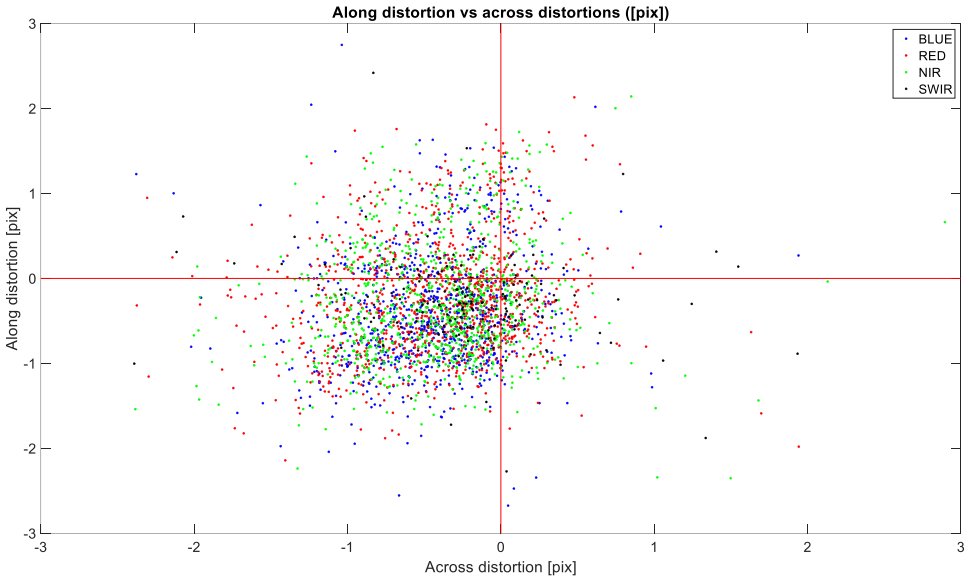

Figure 21: Distortion plots of PROBAV_L1A_20220210_163205_2_V101

PROBAV_L1A_20220310_161000_2_V101

The table below shows the geometric statistics:

Band	Mean across distortion (pixel)	Mean along distortion (pixel)	Number of GCPs
BLUE	0.67985	0.77145	294
NIR	0.71113	0.65646	367
RED	0.73062	0.68612	324
SWIR1	0.37629	0.47943	7
SWIR2	0.37	0.33592	12
SWIR3	0.44209	0.60823	22

Table 4: Geometric statistics of PROBAV_L1A_20220310_161000_2_V101

The figure below shows the distortions plots (across, along track) for all spectral bands.

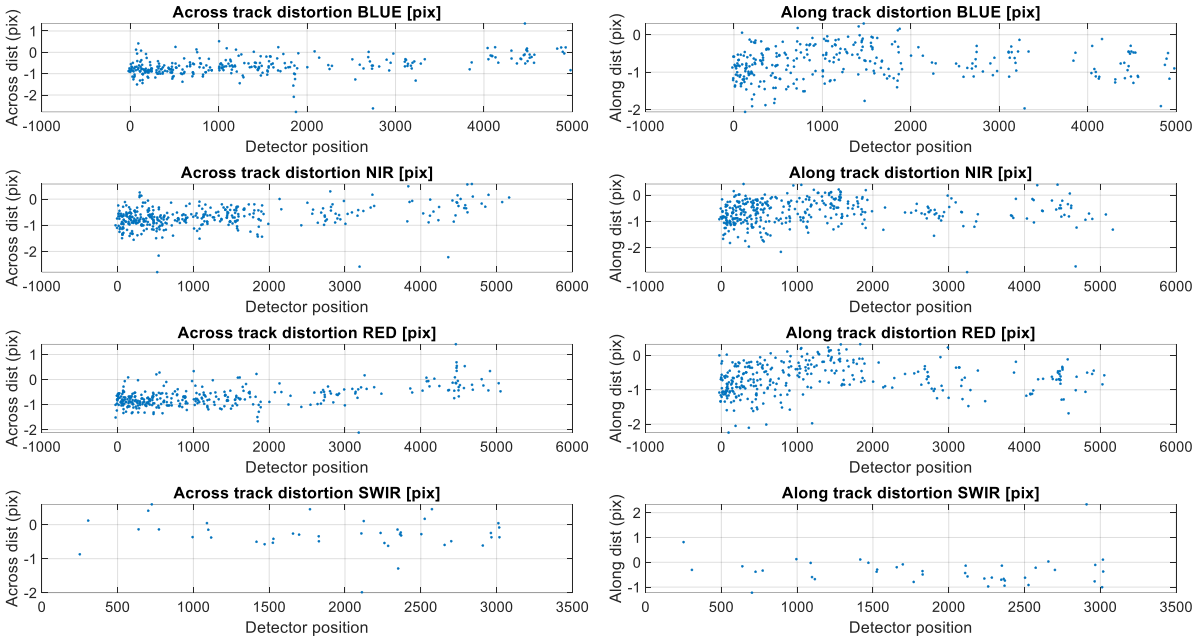

Figure 22: Distortion plots of PROBAV_L1A_20220310_161000_2_V101

The figure below shows the along track distortion in function of the across track distortion in pixels for all spectral bands.

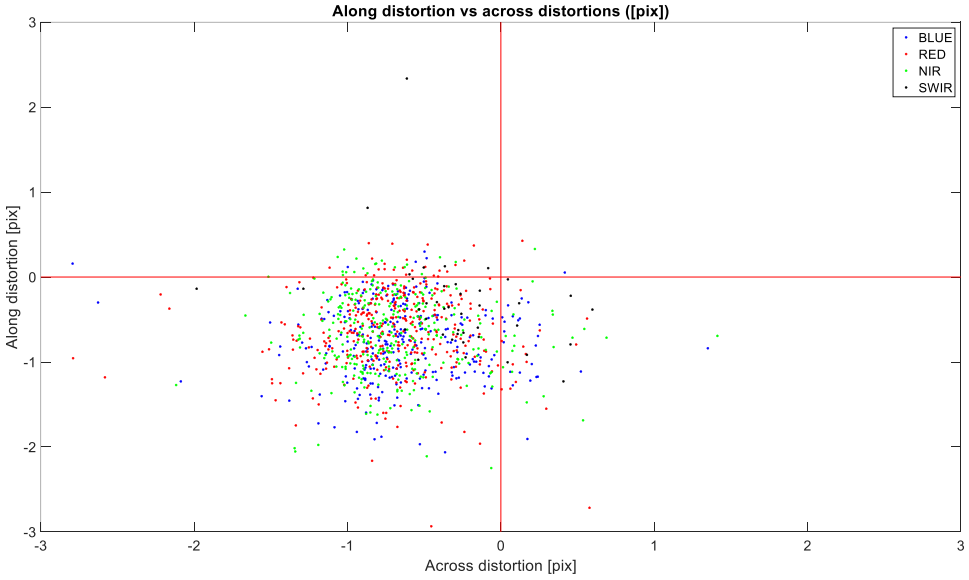

Figure 23: Along track distortion plots of PROBAV_L1A_20220310_161000_2_V101

PROBAV_L1A_20220319_161010_2_V101

The table below shows the geometric statistics:
There are few GCPs to draw reliable statistics, the dataset is probably cloudy!

Band	Mean across distortion (pixel)	Mean along distortion (pixel)	Number of GCPs
BLUE	0.35019	0.41697	67
NIR	0.38347	0.42253	175
RED	0.31973	0.35028	141
SWIR1	0.36627	0.32041	22
SWIR2	0.575	0.476	7
SWIR3	NaN	NaN	0

Table 5: Geometric statistics of PROBAV_L1A_20220319_161010_2_V101

The figure below shows the distortions plots (across, along track) for all spectral bands.

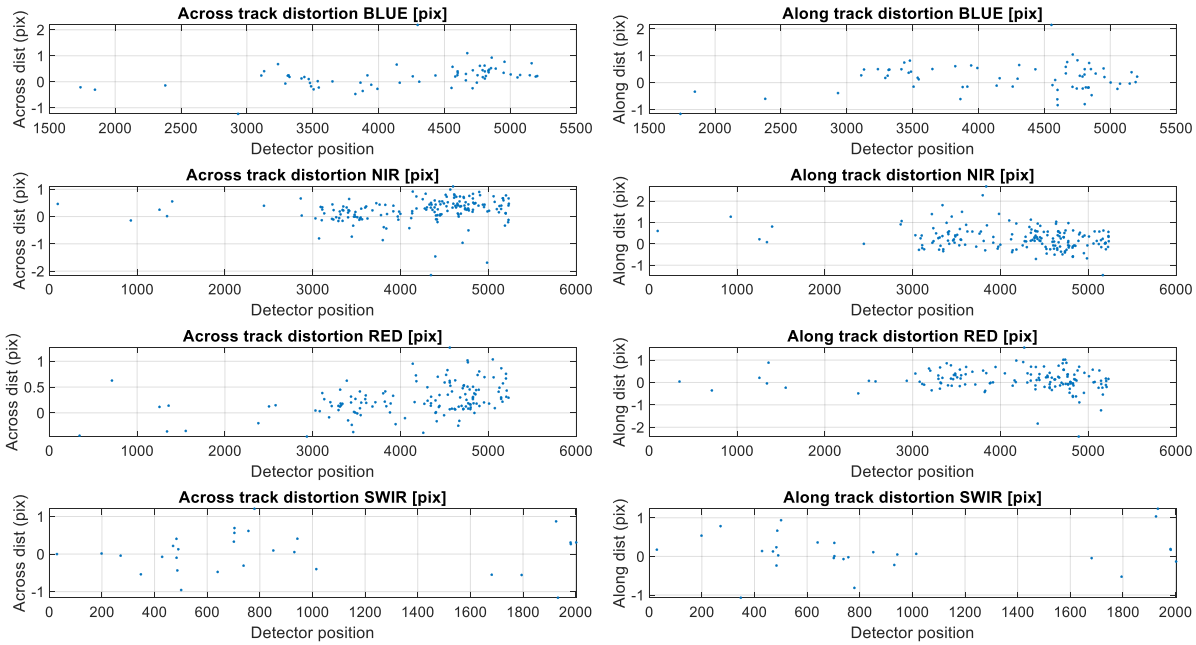

Figure 24: Distortion plots of PROBAV_L1A_20220319_161010_2_V101

The figure below shows the along track distortion in function of the across track distortion in pixels for all spectral bands.

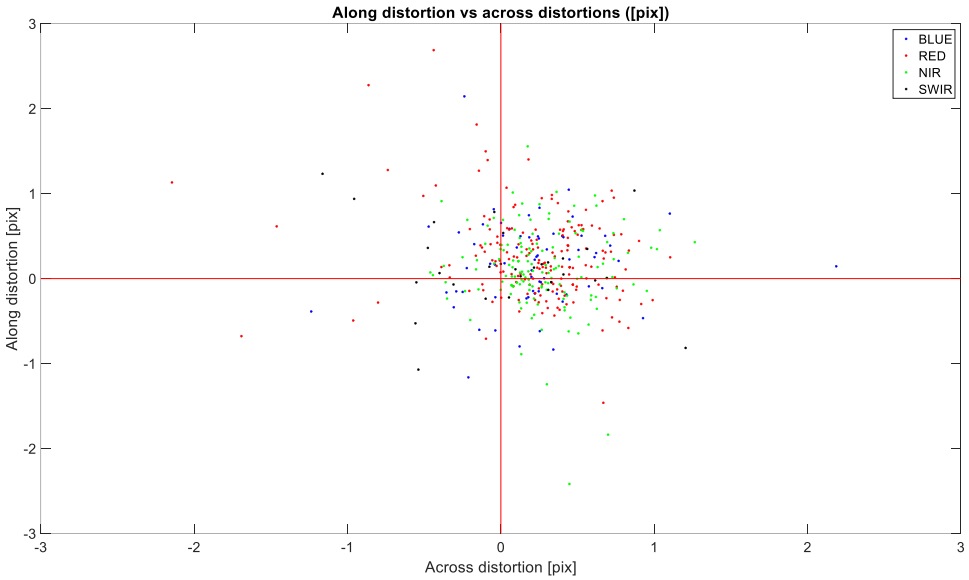

Figure 25: Along track distortion plots of PROBAV_L1A_20220319_161010_2_V101

PROBAV_L1A_20220415_161026_2_V101

The table below shows the geometric statistics:

Band	Mean across distortion (pixel)	Mean along distortion (pixel)	Number of GCPs
BLUE	0.23205	0.41463	938
NIR	0.2331	0.31728	1017
RED	0.25966	0.35657	992
SWIR1	0.1483	0.37379	138
SWIR2	0.16067	0.48994	114
SWIR3	0.23537	0.54321	103

Table 6: Geometric statistics of PROBAV_L1A_20220415_161026_2_V101

The figure below shows the distortions plots (across, along track) for all spectral bands.

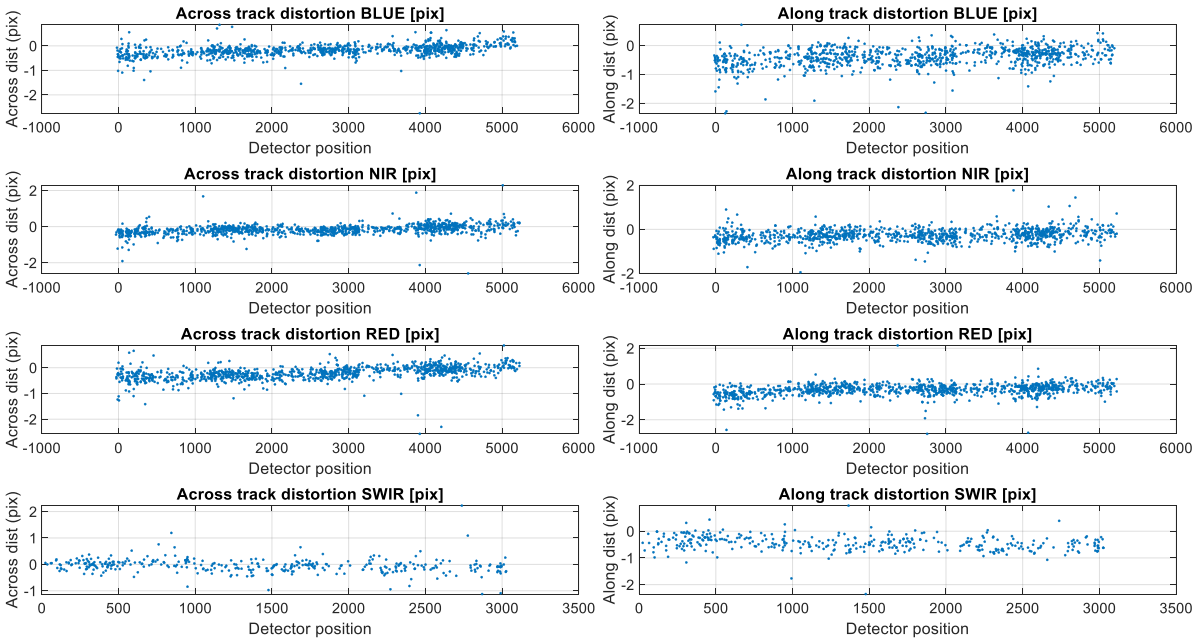

Figure 26: Distortion plots of PROBAV_L1A_20220415_161026_2_V101

The figure below shows the along track distortion in function of the across track distortion in pixels for all spectral bands.

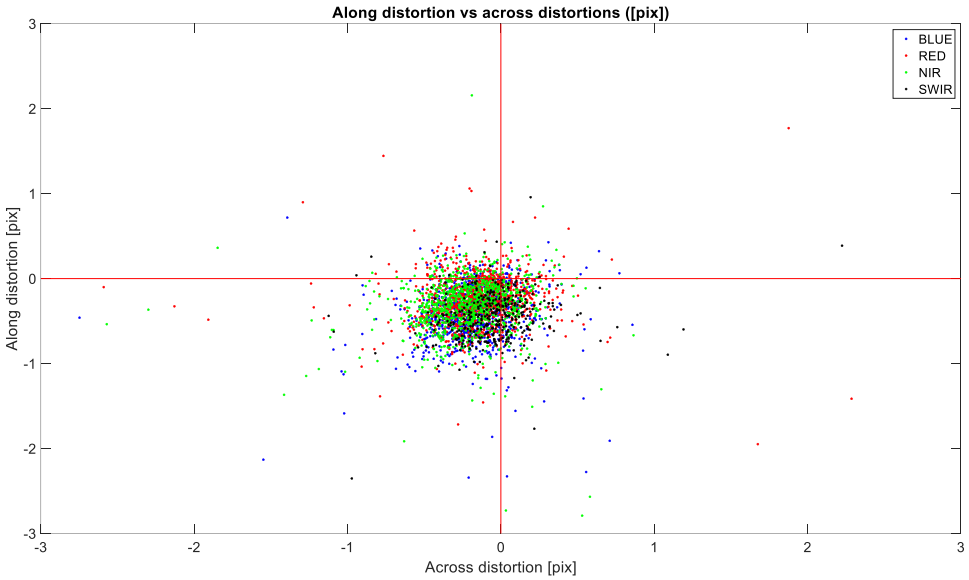

Figure 27: Along track distortion plots of PROBAV_L1A_20220415_161026_2_V101

PROBAV_L1B-CALIBRATION_20220508_155920_2_V101

The table below shows the geometric statistics:

Band	Mean across distortion (pixel)	Mean along distortion (pixel)	Number of GCPs
BLUE	0.21881	0.2536	1161
NIR	0.22865	0.20458	1196
RED	0.2462	0.21708	1178
SWIR1	0.15403	0.32868	202
SWIR2	0.17405	0.32614	143
SWIR3	0.2515	0.45803	119

Table 7: Geometric statistics of PROBAV_L1B-CALIBRATION_20220508_155920_2_V101

The figure below shows the distortions plots (across, along track) for all spectral bands.

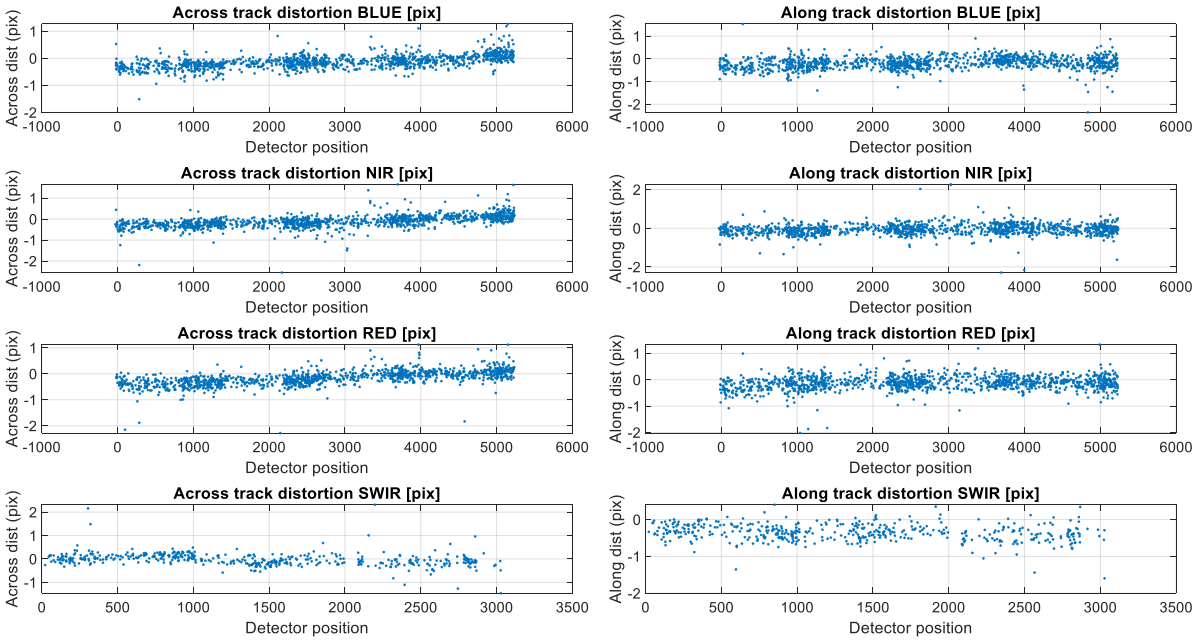

Figure 28: Distortion plots of PROBAV_L1B-CALIBRATION_20220508_155920_2_V101

The figure below shows the along track distortion in function of the across track distortion in pixels for all spectral bands.

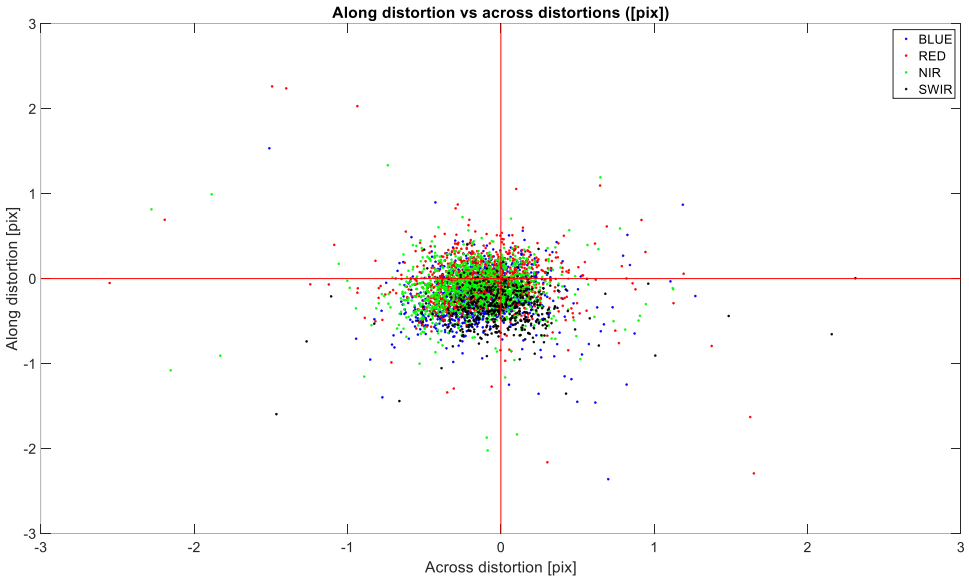

Figure 29: Along track distortion plots of PROBAV_L1B-CALIBRATION_20220508_155920_2_V101

PROBAV_L1B-CALIBRATION_20220608_161040_2_V101

The table below shows the geometric statistics:

Band	Mean across distortion (pixel)	Mean along distortion (pixel)	Number of GCPs
BLUE	0.17402	0.57999	800
NIR	0.17922	0.43618	923
RED	0.18868	0.49165	928
SWIR1	0.14054	0.48644	140
SWIR2	0.14312	0.53931	117
SWIR3	0.17717	0.64269	64

Table 8: Geometric statistics of PROBAV_L1B-CALIBRATION_20220608_161040_2_V101

The figure below shows the distortions plots (across, along track) for all spectral bands.

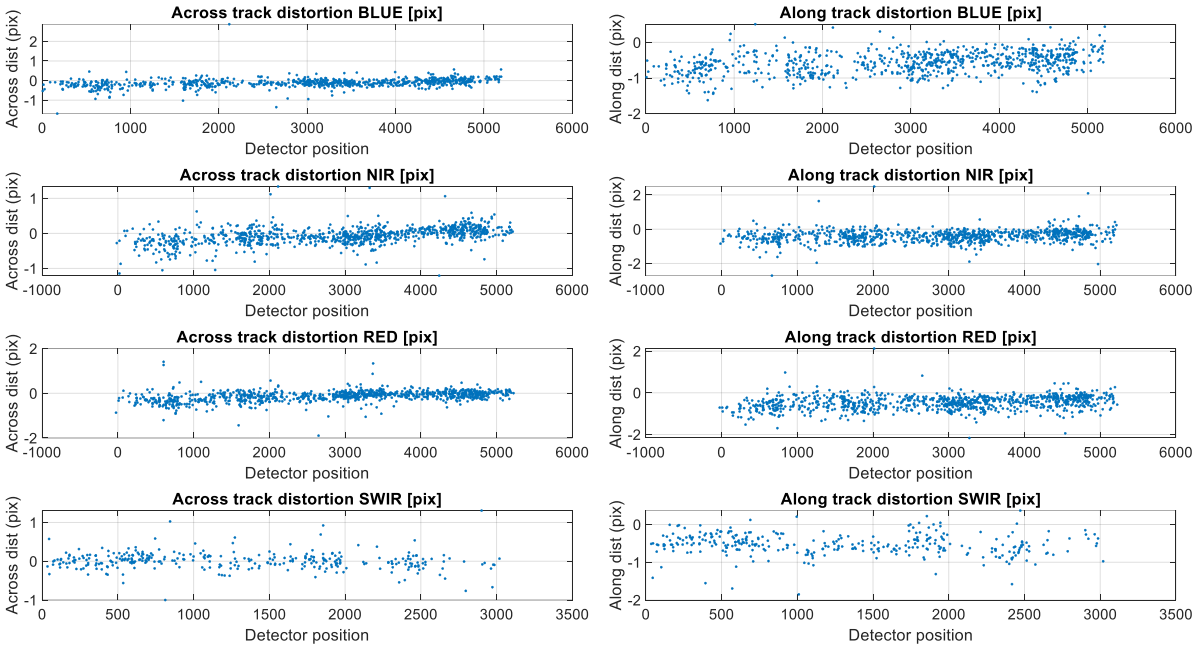

Figure 30: Distortion plots of PROBAV_L1B-CALIBRATION_20220608_161040_2_V101

The figure below shows the along track distortion in function of the across track distortion in pixels for all spectral bands.

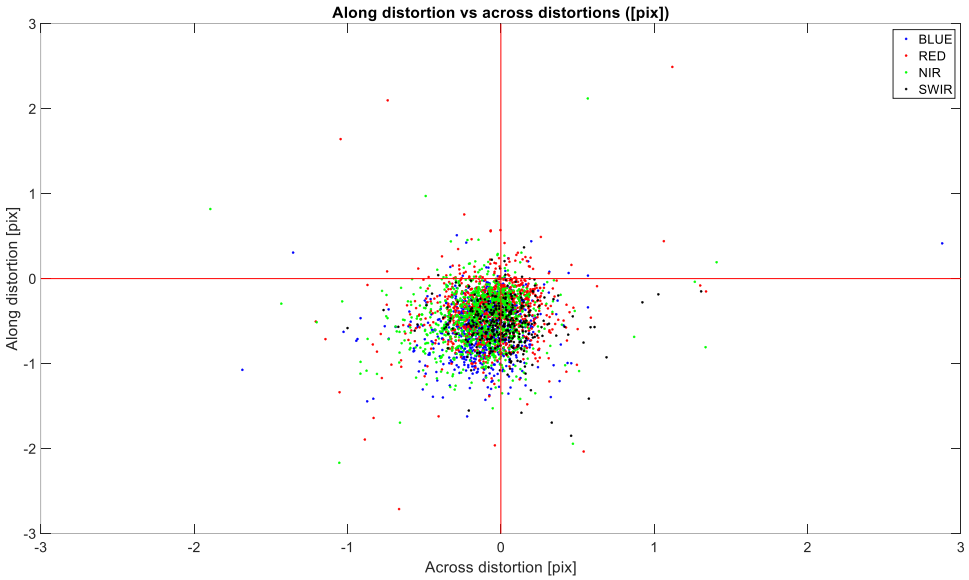

Figure 31: Along track distortion plots of PROBAV_L1B-CALIBRATION_20220608_161040_2_V101

PROBAV_L1B-CALIBRATION_20220613_155921_2_V101

The table below shows the geometric statistics:

Band	Mean across distortion (pixel)	Mean along distortion (pixel)	Number of GCPs
BLUE	0.23858	0.69901	915
NIR	0.23595	0.56343	966
RED	0.28058	0.614	955
SWIR1	0.13726	0.50236	123
SWIR2	0.191	0.58976	98
SWIR3	0.27459	0.70207	96

Table 9: Geometric statistics of PROBAV_L1B-CALIBRATION_20220613_155921_2_V101

The figure below shows the distortions plots (across, along track) for all spectral bands.

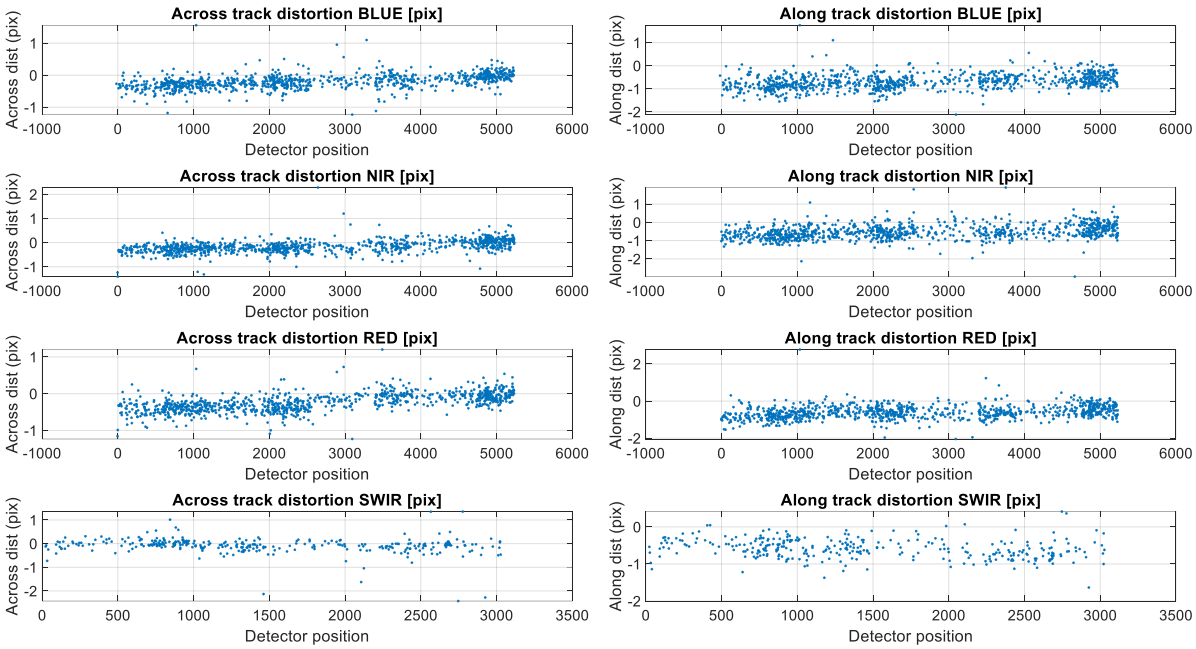

Figure 32: Distortion plots of PROBAV_L1B-CALIBRATION_20220613_155921_2_V101

The figure below shows the along track distortion in function of the across track distortion in pixels for all spectral bands.

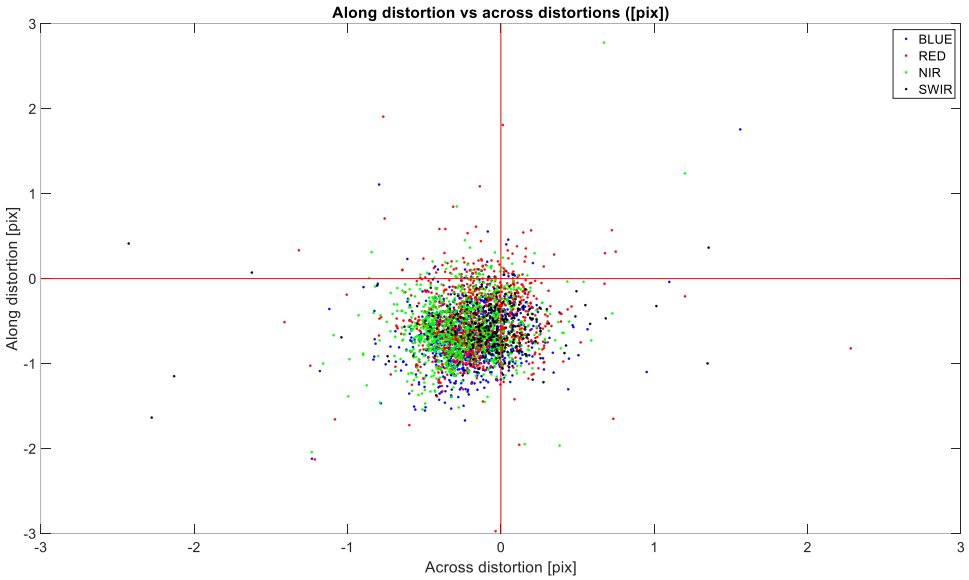

Figure 33: Along track distortion plots of PROBAV_L1B-CALIBRATION_20220613_155921_2_V101

PROBAV_L1B-CALIBRATION_20220617_161036_2_V101

The table below shows the geometric statistics:

Band	Mean across distortion (pixel)	Mean along distortion (pixel)	Number of GCPs
BLUE	0.1748	0.37297	567
NIR	0.18724	0.30508	606
RED	0.17184	0.31516	616
SWIR1	0.14721	0.34064	204
SWIR2	0.2155	0.35835	20
SWIR3	0.14169	0.62562	32

Table 10: Geometric statistics of PROBAV_L1B-CALIBRATION_20220617_161036_2_V101

The figure below shows the distortions plots (across, along track) for all spectral bands.

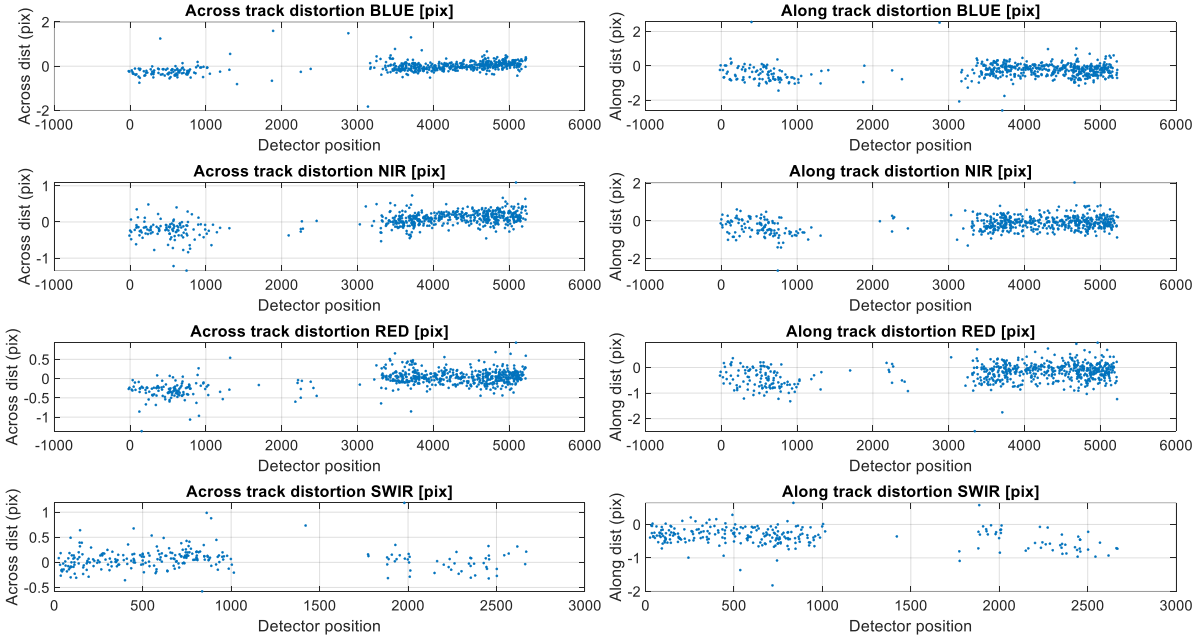

Figure 34: Distortion plots of PROBAV_L1B-CALIBRATION_20220617_161036_2_V101

The figure below shows the along track distortion in function of the across track distortion in pixels for all spectral bands.

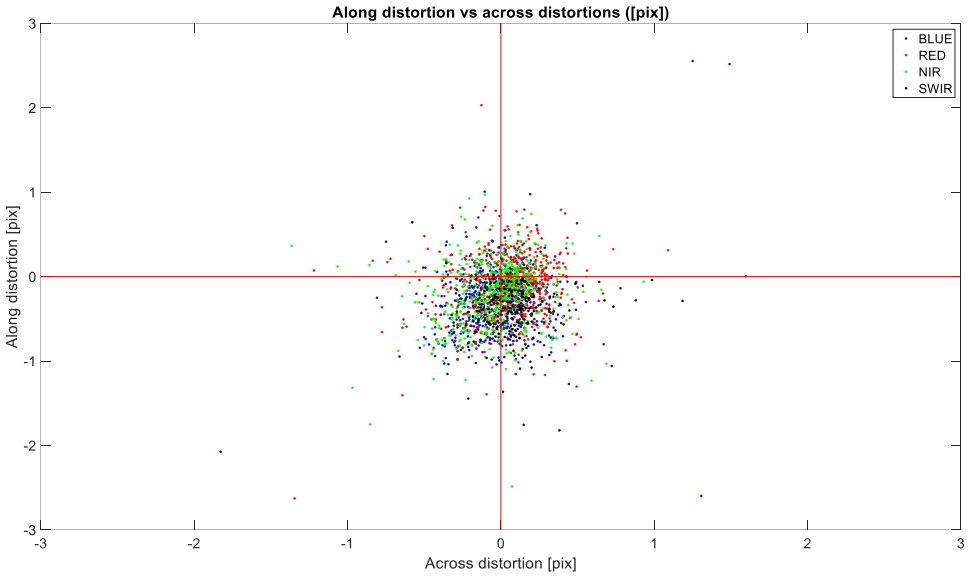

Figure 35: Along track distortion plots of PROBAV_L1B-CALIBRATION_20220617_161036_2_V101

PROBAV_L1B-CALIBRATION_20220710_155915_2_V101

The table below shows the geometric statistics:

Band	Mean across distortion (pixel)	Mean along distortion (pixel)	Number of GCPs
BLUE	0.16953	0.59332	1193
NIR	0.17067	0.4558	1193
RED	0.19758	0.5255	1206
SWIR1	0.15295	0.45072	123
SWIR2	0.15991	0.52964	190
SWIR3	0.2454	0.65375	153

Table 11: Geometric statistics of PROBAV_L1B-CALIBRATION_20220710_155915_2_V101

The figure below shows the distortions plots (across, along track) for all spectral bands.

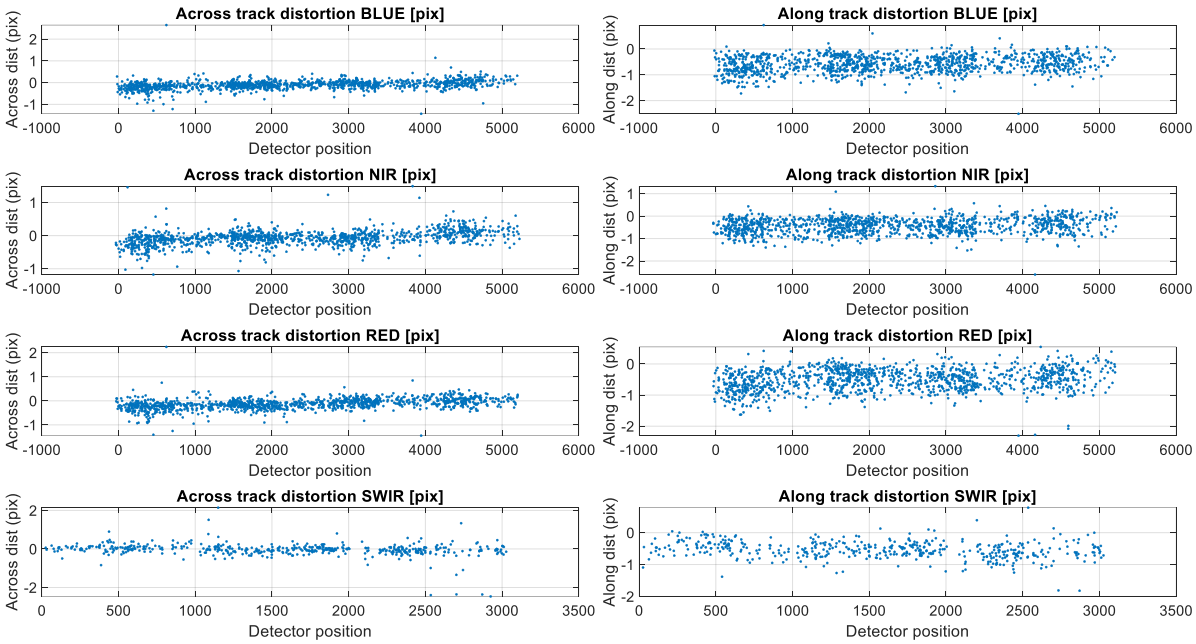

Figure 36: Distortion plots of PROBAV_L1B-CALIBRATION_20220710_155915_2_V101

The figure below shows the along track distortion in function of the across track distortion in pixels for all spectral bands.

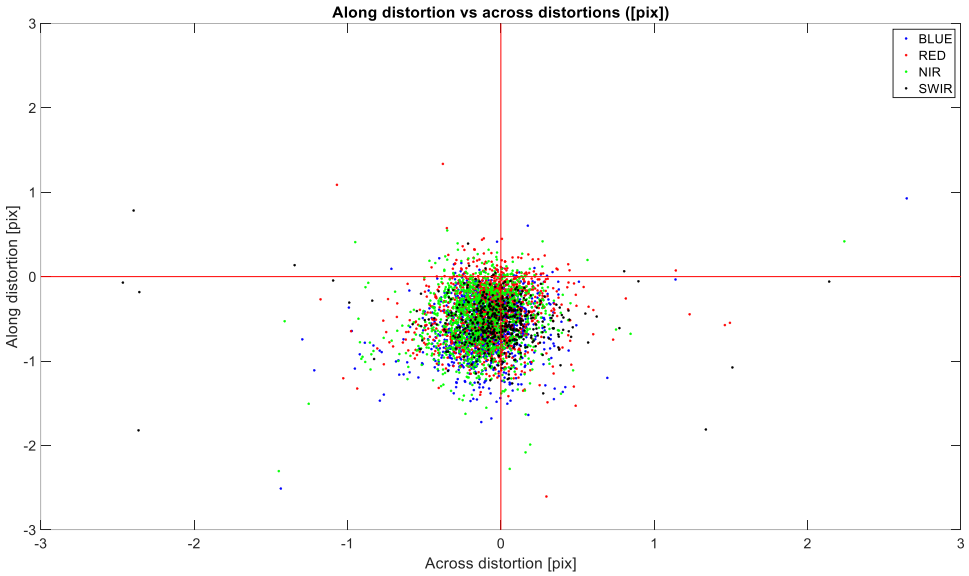

Figure 37: Along track distortion plots of PROBAV_L1B-CALIBRATION_20220710_155915_2_V101

PROBAV_L1B-CALIBRATION_20220719_155911_2_V101

The table below shows the geometric statistics:

Band	Mean across distortion (pixel)	Mean along distortion (pixel)	Number of GCPs
BLUE	0.21593	0.41411	1165
NIR	0.20689	0.27803	1177
RED	0.23731	0.33244	1206
SWIR1	0.15394	0.35701	151
SWIR2	0.1574	0.4237	164
SWIR3	0.26456	0.54212	104

*Table 12: Geometric statistics of PROBAV*_L1B-CALIBRATION_20220719_155911_2_V101

The figure below shows the distortions plots (across, along track) for all spectral bands.

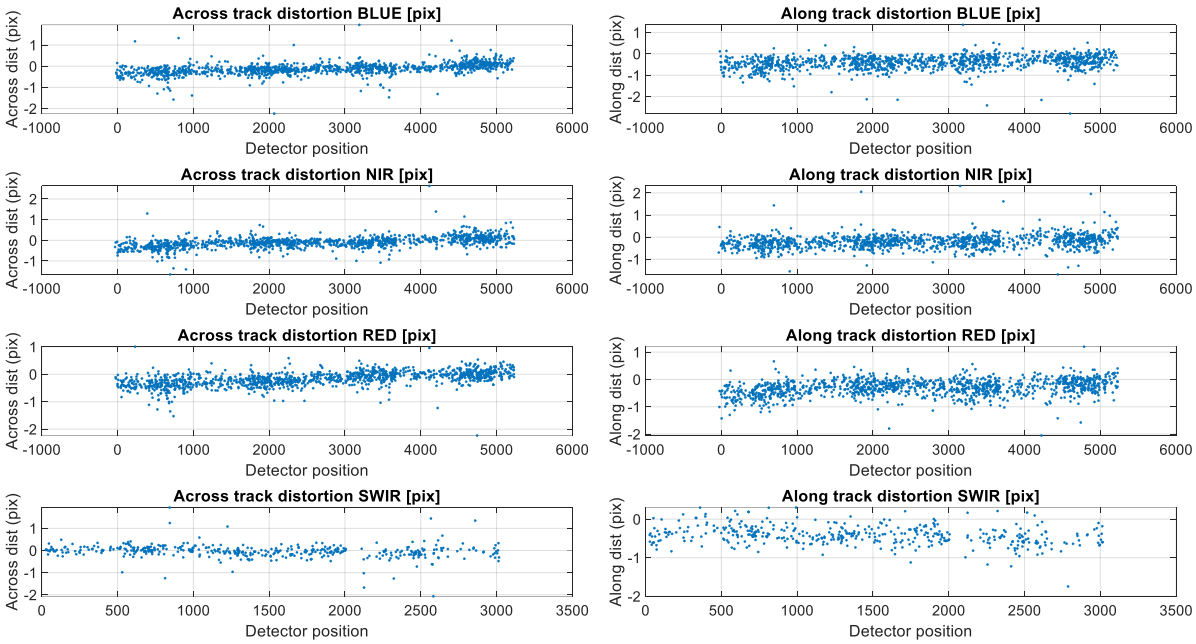

Figure 38: Distortion plots of PROBAV_L1B-CALIBRATION_20220719_155911_2_V101

The figure below shows the along track distortion in function of the across track distortion in pixels for all spectral bands.

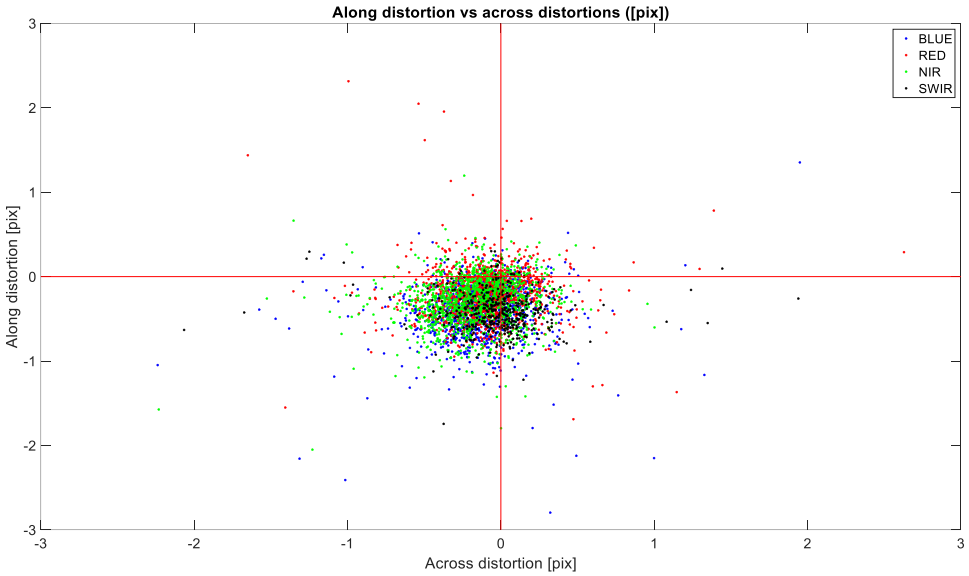

Figure 39: Along track distortion plots of PROBAV_L1B-CALIBRATION_20220719_155911_2_V101

PROBAV_L1B-CALIBRATION_20220806_155905_2_V101

The table below shows the geometric statistics:

Band	Mean across distortion (pixel)	Mean along distortion (pixel)	Number of GCPs
BLUE	0.42015	0.80784	679
NIR	0.38443	0.65627	780
RED	0.42725	0.72553	774
SWIR1	0.21562	0.32831	68
SWIR2	0.25557	0.31952	23
SWIR3	0.37295	0.55124	63

Table 13: Geometric statistics of PROBAV_L1B-CALIBRATION_20220806_155905_2_V101

The figure below shows the distortions plots (across, along track) for all spectral bands.

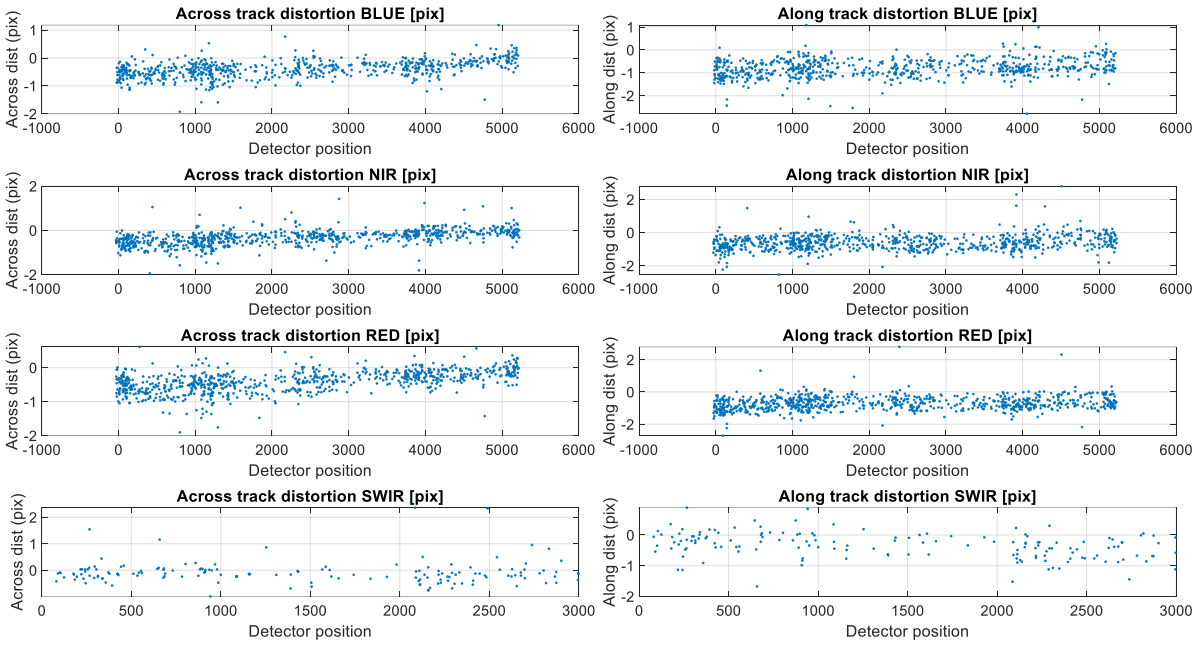

Figure 40: Distortion plots of PROBAV_L1B-CALIBRATION_20220806_155905_2_V101

The figure below shows the along track distortion in function of the across track distortion in pixels for all spectral bands.

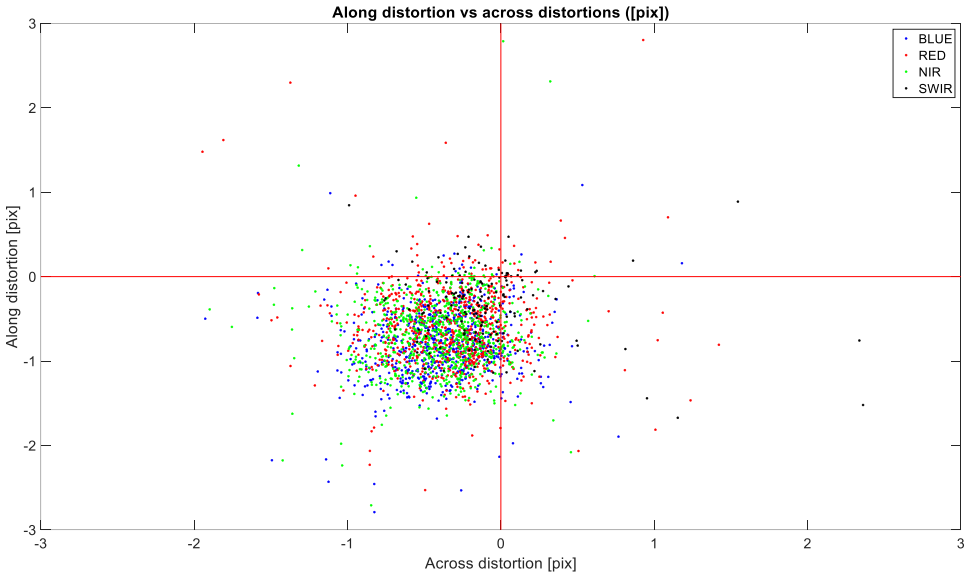

Figure 41: Along track distortion plots of PROBAV_L1B-CALIBRATION_20220806_155905_2_V101

PROBAV_L1B-CALIBRATION_20220815_155901_2_V101

The table below shows the geometric statistics:

Band	Mean across distortion (pixel)	Mean along distortion (pixel)	Number of GCPs
BLUE	0.31801	0.48958	1263
NIR	0.28466	0.38108	1237
RED	0.33731	0.43006	1252
SWIR1	0.18846	0.21177	94
SWIR2	0.27391	0.28805	166
SWIR3	0.27748	0.36912	132

Table 14: Geometric statistics of PROBAV_L1B-CALIBRATION_20220815_155901_2_V101

The figure below shows the distortions plots (across, along track) for all spectral bands.

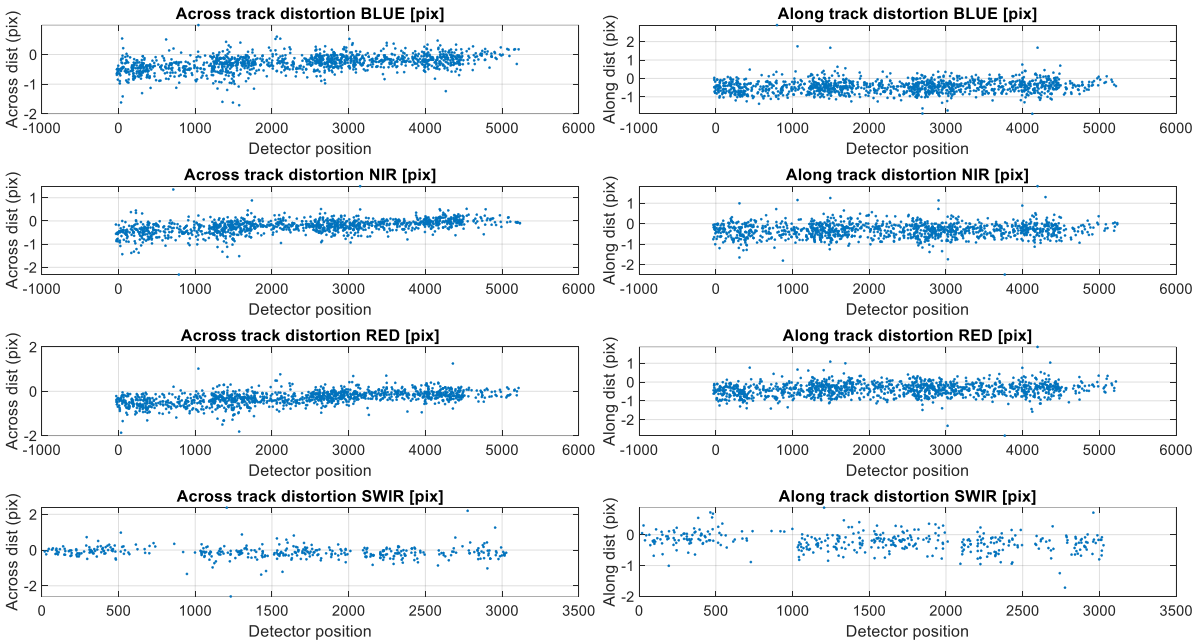

Figure 42: Distortion plots of PROBAV_L1B-CALIBRATION_20220815_155901_2_V101

The figure below shows the along track distortion in function of the across track distortion in pixels for all spectral bands.

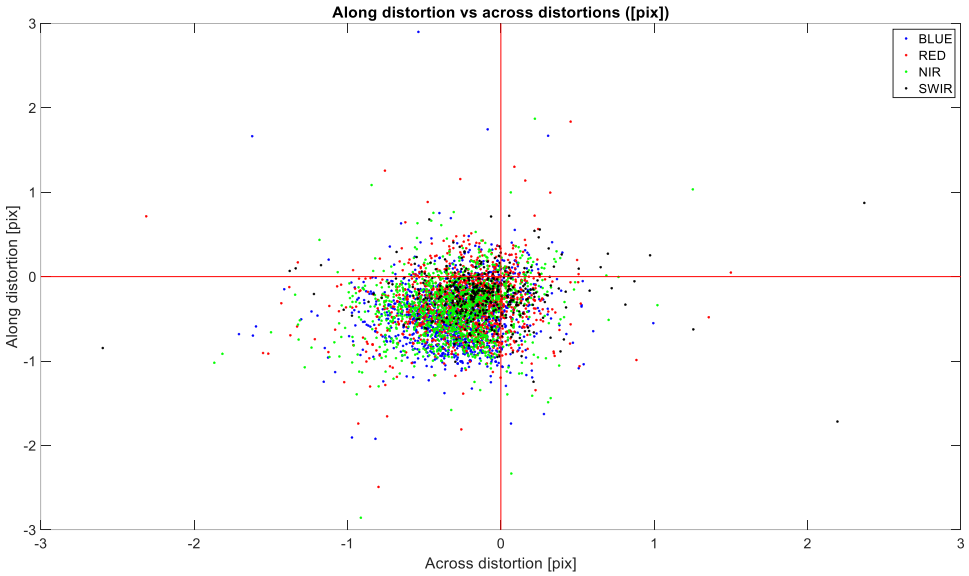

Figure 43: Along track distortion plots of PROBAV_L1B-CALIBRATION_20220815_155901_2_V101

PROBAV_L1B-CALIBRATION_20220820_154741_2_V101

The table below shows the geometric statistics:

Band	Mean across distortion (pixel)	Mean along distortion (pixel)	Number of GCPs
BLUE	0.21073	0.30598	1058
NIR	0.24205	0.26252	1053
RED	0.24629	0.28361	1075
SWIR1	0.25072	0.19406	94
SWIR2	0.23103	0.18374	77
SWIR3	0.3022	0.26687	97

Table 15: Geometric statistics of PROBAV_L1B-CALIBRATION_20220820_154741_2_V101

The figure below shows the distortions plots (across, along track) for all spectral bands.

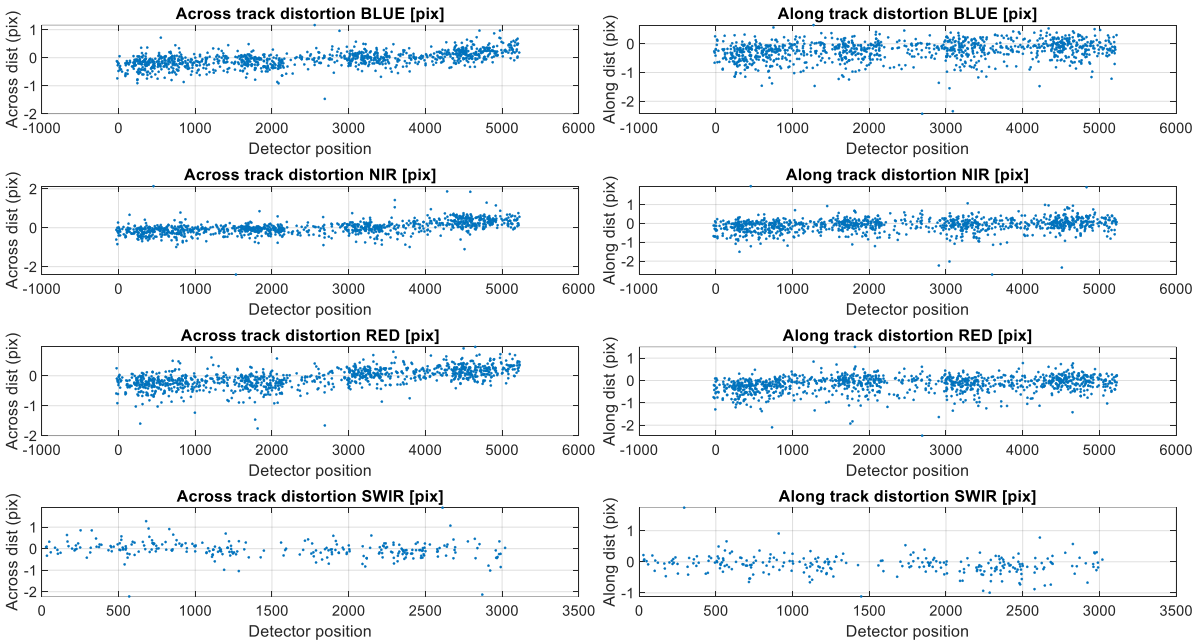

Figure 44: Distortion plots of PROBAV_L1B-CALIBRATION_20220820_154741_2_V101

The figure below shows the along track distortion in function of the across track distortion in pixels for all spectral bands.

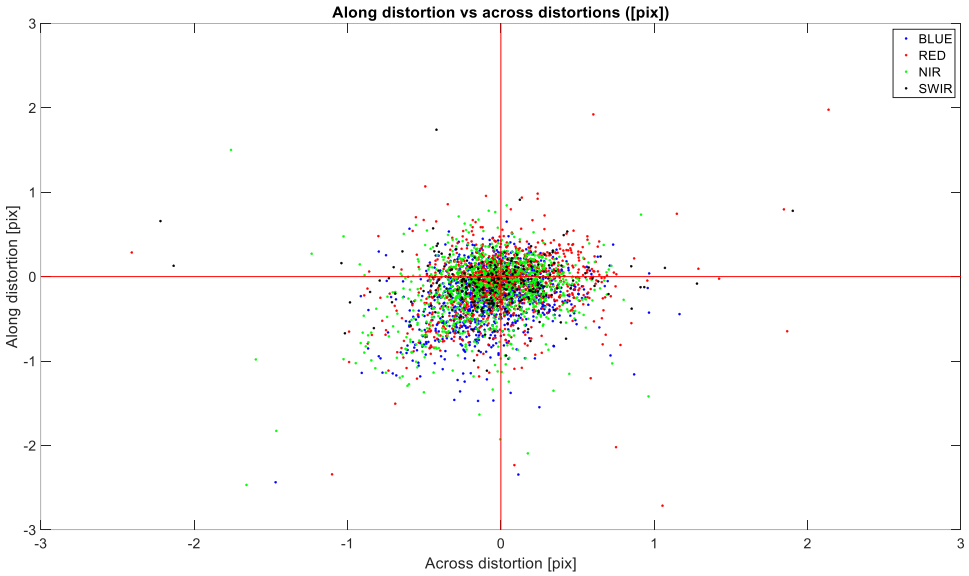

Figure 45: Along track distortion plots of PROBAV_L1B-CALIBRATION_20220820_154741_2_V101

PROBAV_L1B-CALIBRATION_20220824_155855_2_V101

The table below shows the geometric statistics:

Band	Mean across distortion (pixel)	Mean along distortion (pixel)	Number of GCPs
BLUE	0.23045	0.32828	891
NIR	0.2528	0.33894	910
RED	0.25737	0.32626	935
SWIR1	0.17164	0.28857	47
SWIR2	0.18785	0.1663	123
SWIR3	0.24953	0.26745	97

Table 16: Geometric statistics of PROBAV_L1B-CALIBRATION_20220824_155855_2_V101

The figure below shows the distortions plots (across, along track) for all spectral bands.

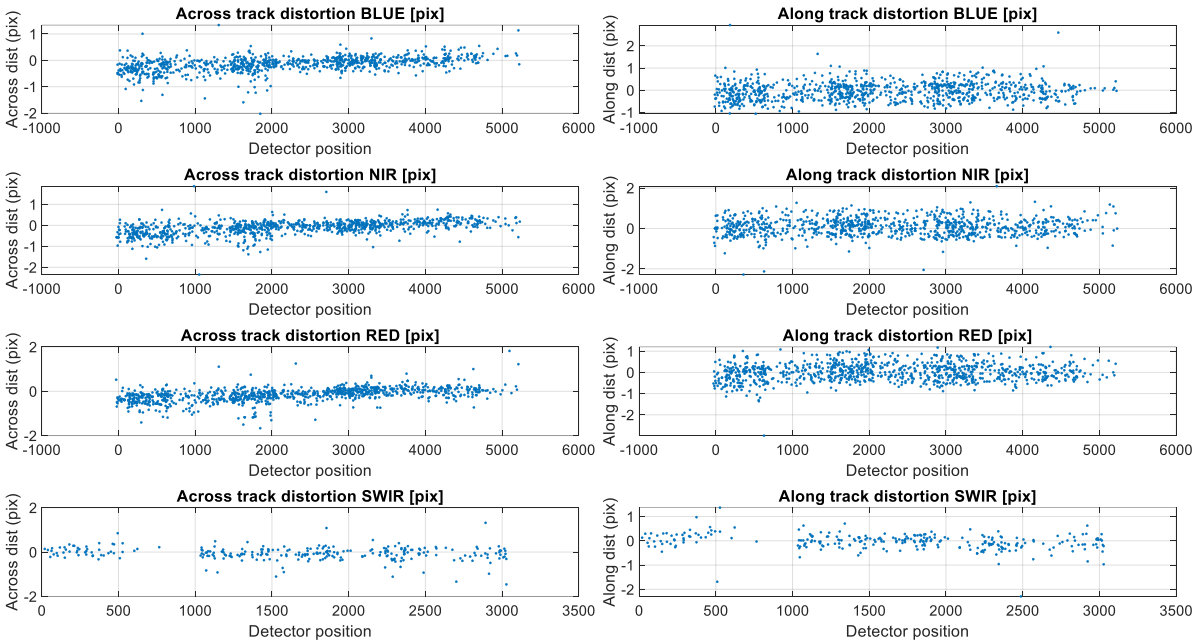

Figure 46: Distortion plots of PROBAV_L1B-CALIBRATION_20220824_155855_2_V101

The figure below shows the along track distortion in function of the across track distortion in pixels for all spectral bands.

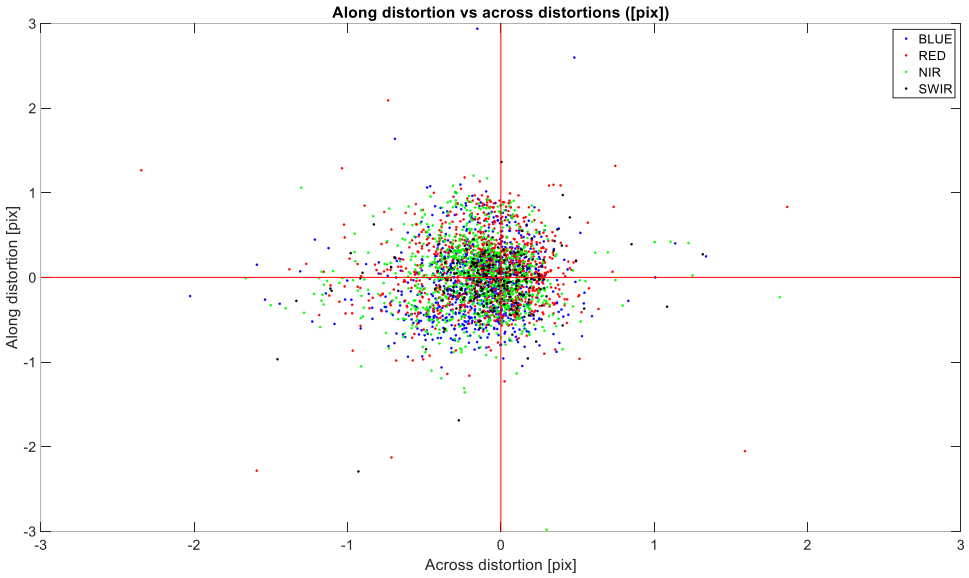

Figure 47: Along track distortion plots of PROBAV_L1B-CALIBRATION_20220824_155855_2_V101

PROBAV_L1B-CALIBRATION_20220829_154736_2_V101

The table below shows the geometric statistics:

Band	Mean across distortion (pixel)	Mean along distortion (pixel)	Number of GCPs
BLUE	0.22999	0.33807	1343
NIR	0.2405	0.31867	1321
RED	0.25788	0.31254	1345
SWIR1	0.20693	0.19917	162
SWIR2	0.22834	0.22021	127
SWIR3	0.28022	0.2718	116

Table 17: Geometric statistics of PROBAV_L1B-CALIBRATION_20220829_154736_2_V101

The figure below shows the distortions plots (across, along track) for all spectral bands.

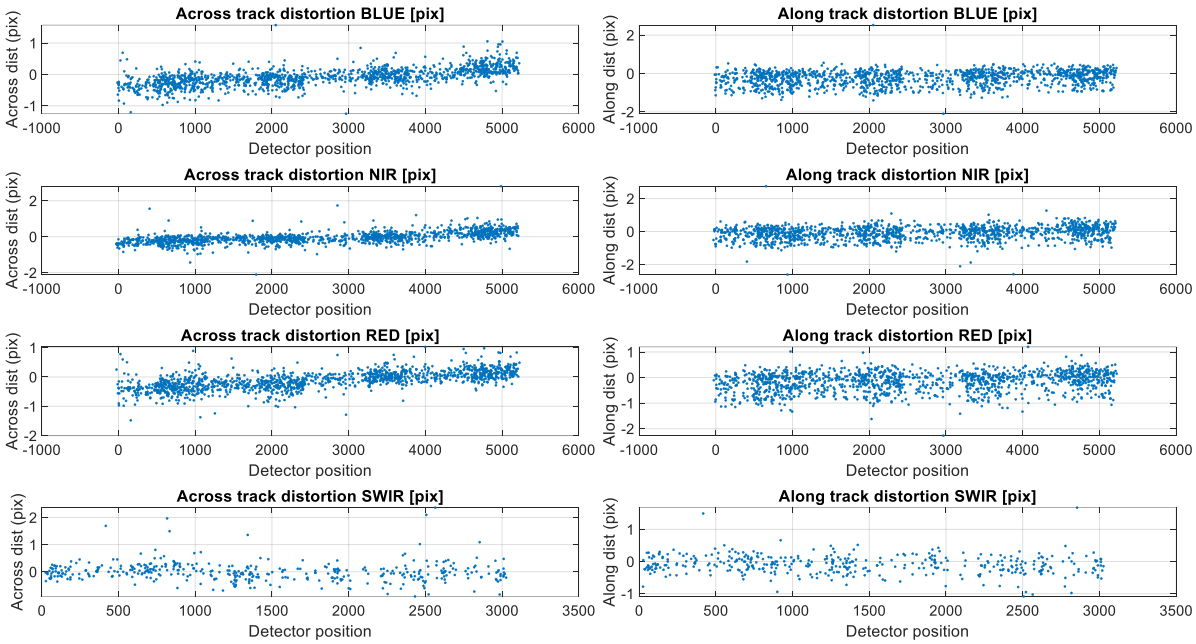

Figure 48: Distortion plots of PROBAV_L1B-CALIBRATION_20220829_154736_2_V101

The figure below shows the along track distortion in function of the across track distortion in pixels for all spectral bands.

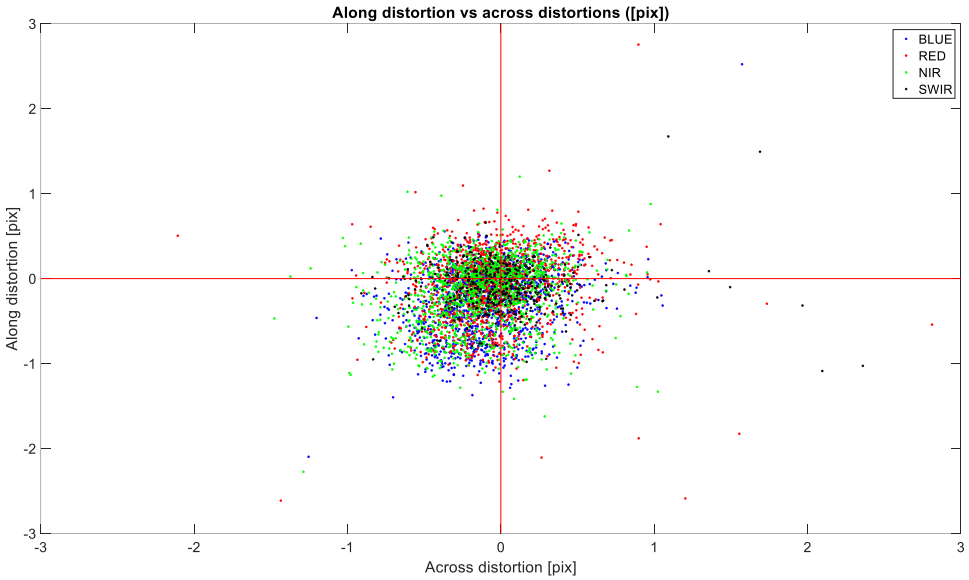

Figure 49: Along track distortion plots of PROBAV_L1B-CALIBRATION_20220829_154736_2_V101

3.1.1. Summary

The figure below shows the summary for the along/across track distortion in pixels (all acquisition, all spectral bands). Conclusion is that no major geometric anomalies are observed based on Railroad Valley acquisitions.

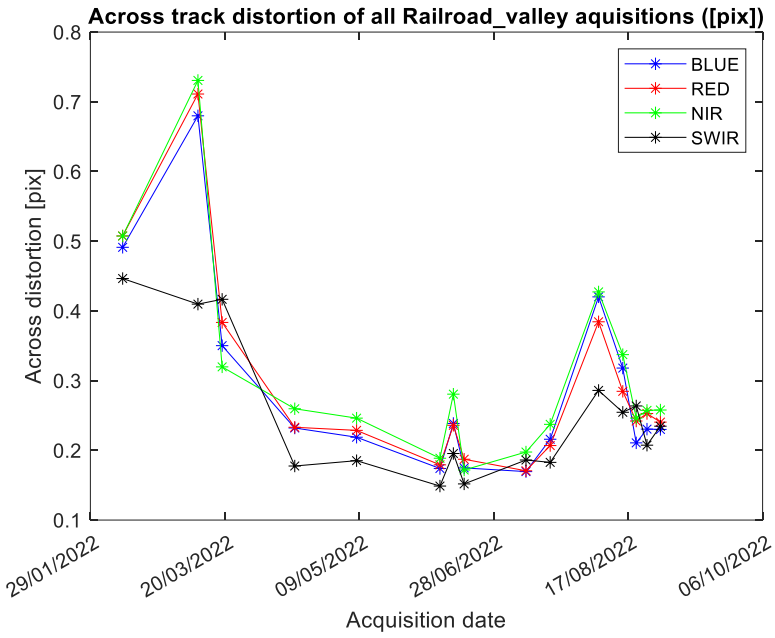

Figure 50 - Across track distortions based on Railroad valley acquisitions

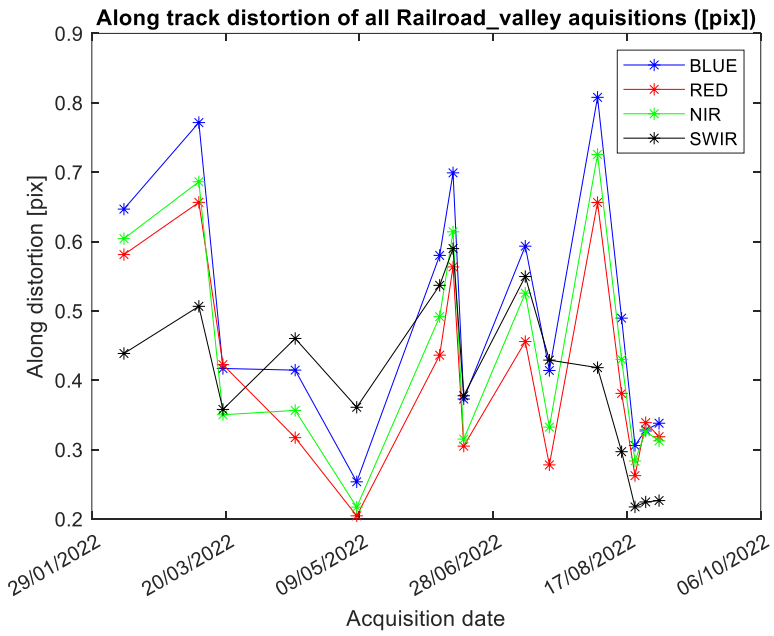

Figure 51 - Along track distortions based on Railroad valley acquisitions

3.2. Gobabeb

PROBAV_L1A_20220709_063155_2_V101

The table below shows the geometric statistics:

Band	Mean across distortion (pixel)	Mean along distortion (pixel)	Number of GCPs
BLUE	0.34862	0.29534	540
NIR	0.45517	0.41938	489
RED	0.43151	0.36184	509
SWIR1	0.38695	0.26946	57
SWIR2	0.38861	0.30703	117
SWIR3	0.68973	0.18718	11

Table 18: Geometric statistics of PROBAV_L1A_20220709_063155_2_V101

The figure below shows the distortions plots (across, along track) for all spectral bands.

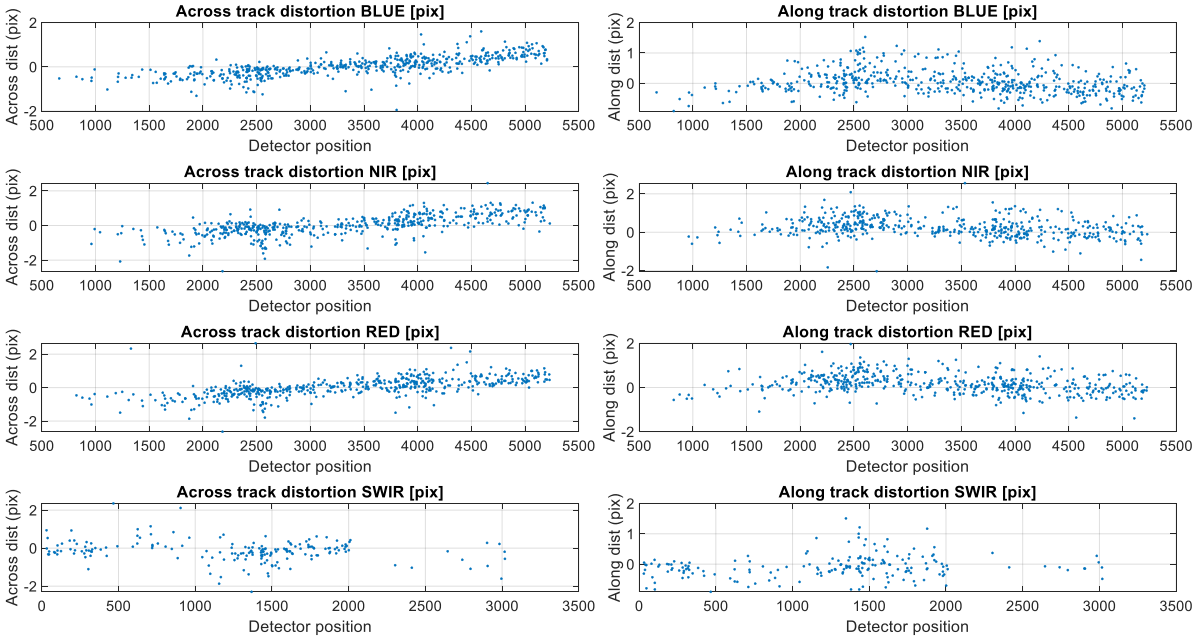

Figure 52: Distortion plots of PROBAV_L1A_20220709_063155_2_V101

The figure below shows the along track distortion in function of the across track distortion in pixels for all spectral bands.

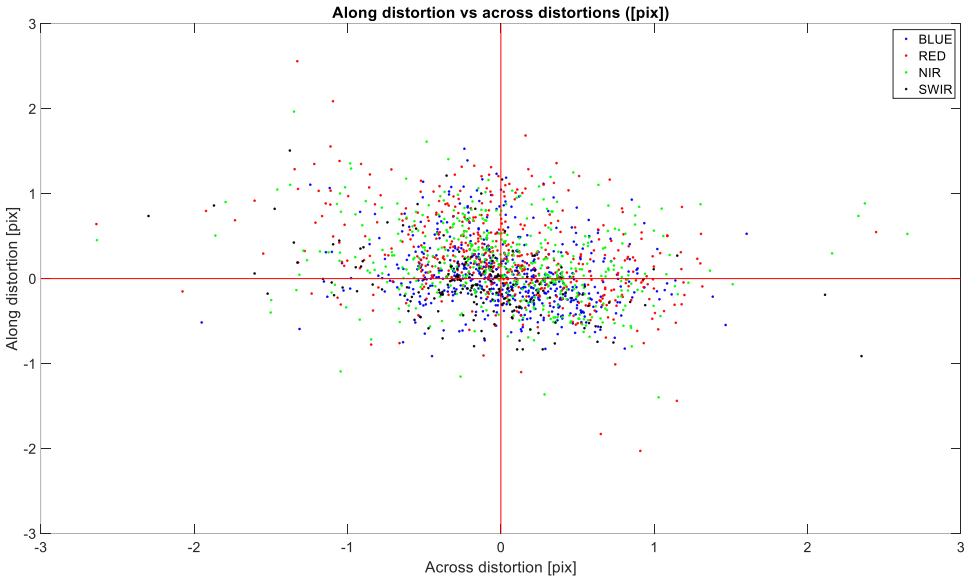

Figure 53: Along track distortion plots of PROBAV_L1A_20220709_063155_2_V101

PROBAV_L1A_20220713_064305_2_V101

The table below shows the geometric statistics:
There are few GCPs to draw reliable statistics, the dataset is probably cloudy!

Band	Mean across distortion (pixel)	Mean along distortion (pixel)	Number of GCPs
BLUE	0.3413	0.49207	172
NIR	0.45984	0.6767	185
RED	0.33202	0.62725	182
SWIR1	0.32629	0.24894	95
SWIR2	0.32867	0.137	3
SWIR3	NaN	NaN	0

Table 19: Geometric statistics of PROBAV_L1A_20220713_064305_2_V101

The figure below shows the distortions plots (across, along track) for all spectral bands.

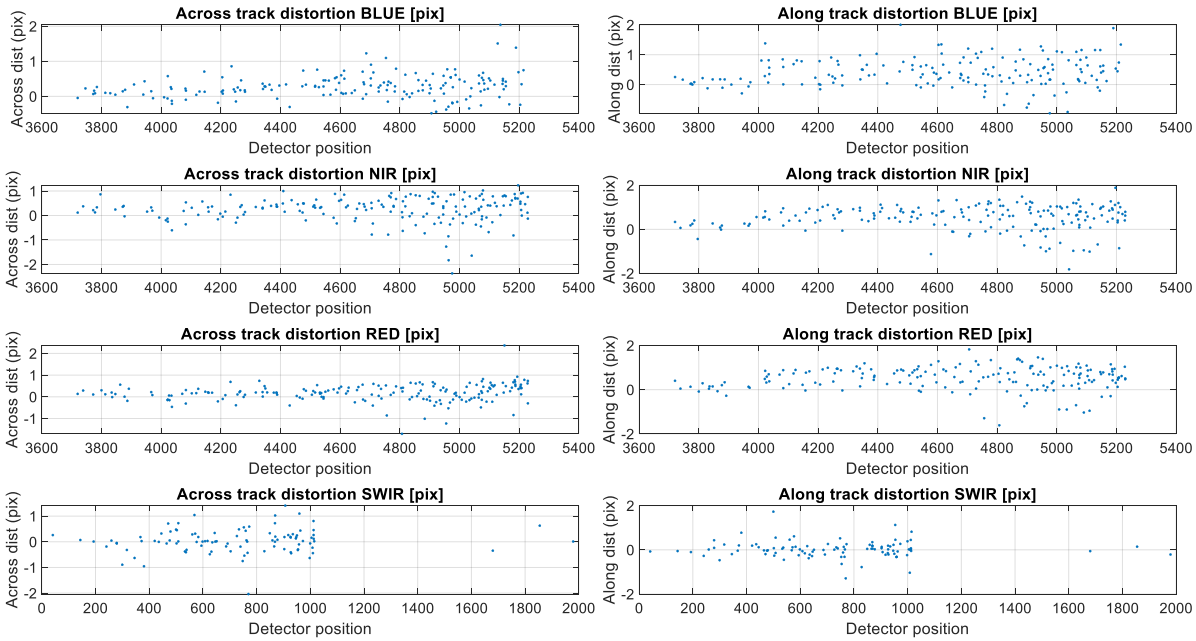

Figure 54: Distortion plots of PROBAV_L1A_20220713_064305_2_V101

The figure below shows the along track distortion in function of the across track distortion in pixels for all spectral bands.

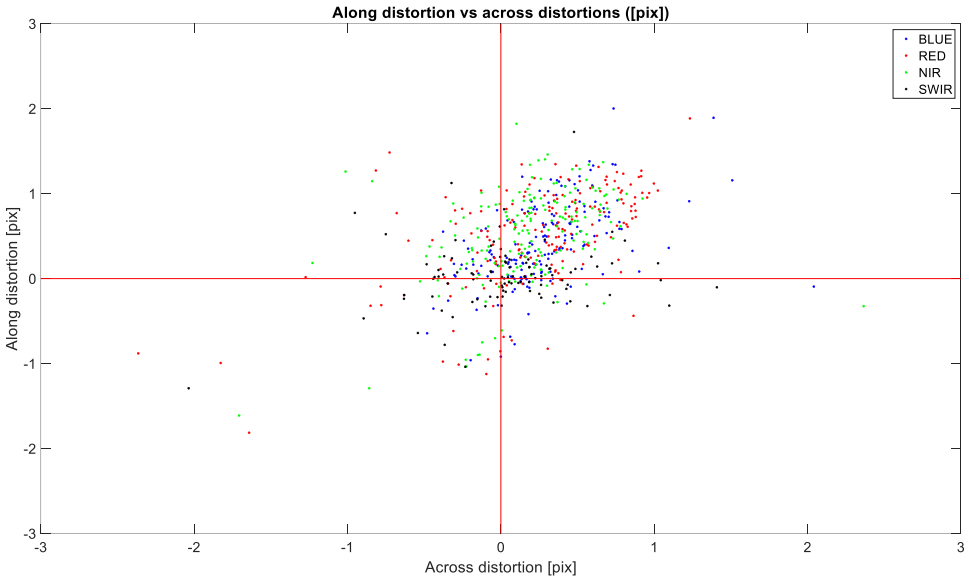

Figure 55: Along track distortion plots of PROBAV_L1A_20220713_064305_2_V101

PROBAV_L1A_20220718_063151_2_V101

The table below shows the geometric statistics:

Band	Mean across distortion (pixel)	Mean along distortion (pixel)	Number of GCPs
BLUE	0.36471	0.30861	654
NIR	0.46919	0.47123	628
RED	0.45329	0.42548	652
SWIR1	0.42848	0.22293	80
SWIR2	0.42366	0.26513	121
SWIR3	0.64	0.32044	18

Table 20: Geometric statistics of PROBAV_L1A_20220718_063151_2_V101

The figure below shows the distortions plots (across, along track) for all spectral bands.

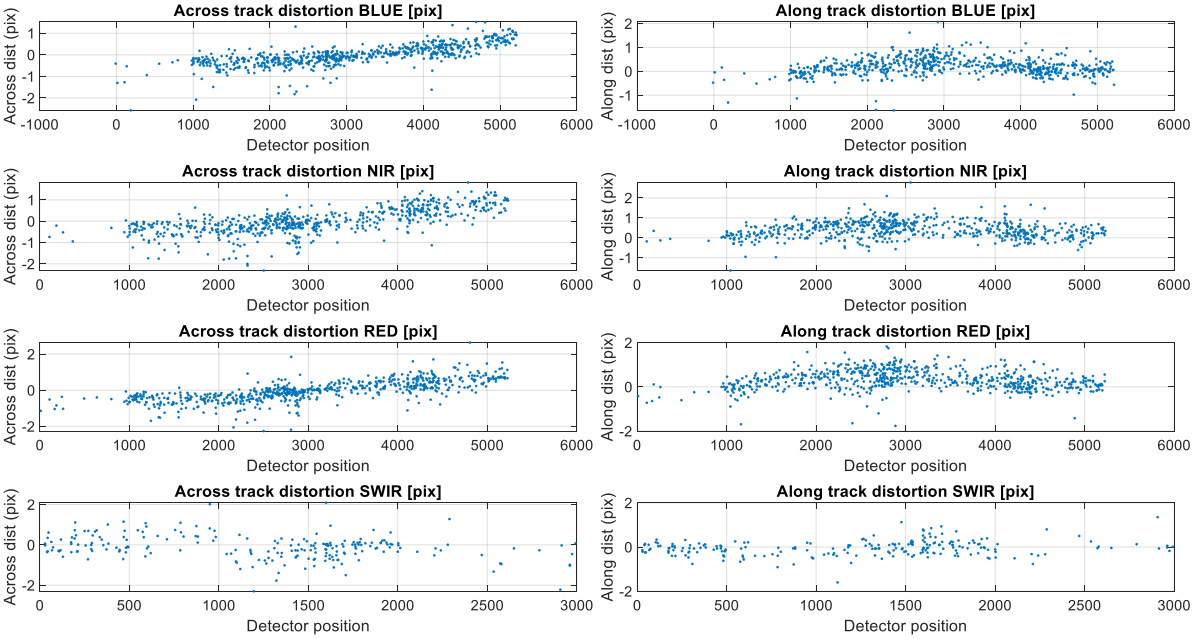

Figure 56: Distortion plots of PROBAV_L1A_20220718_063151_2_V101

The figure below shows the along track distortion in function of the across track distortion in pixels for all spectral bands.

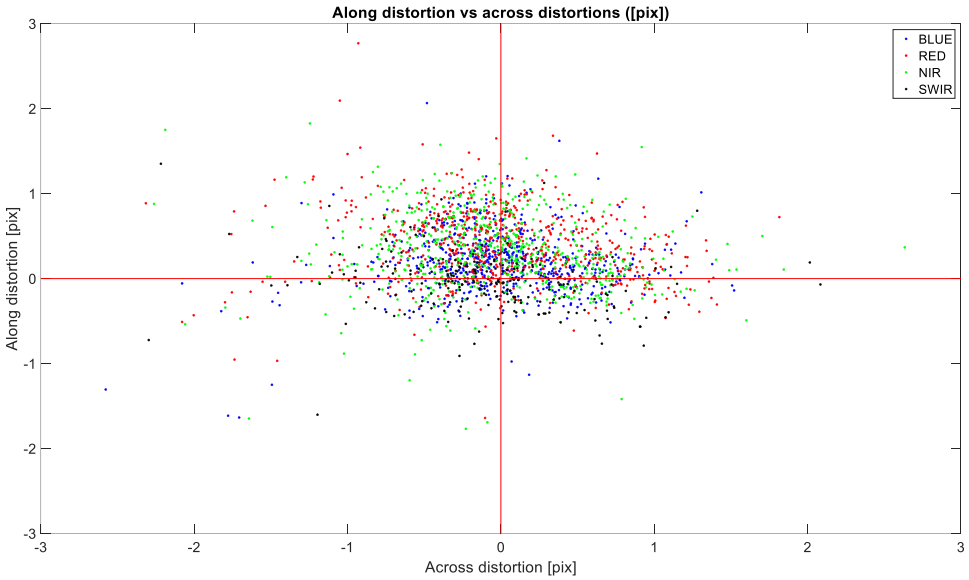

Figure 57: Along track distortion plots of PROBAV_L1A_20220718_063151_2_V101

PROBAV_L1A_20220722_064306_2_V101

The table below shows the geometric statistics:
There are few GCPs to draw reliable statistics, the dataset is probably cloudy!

Band	Mean across distortion (pixel)	Mean along distortion (pixel)	Number of GCPs
BLUE	0.3191	0.31664	134
NIR	0.41021	0.37919	118
RED	0.26507	0.33452	122
SWIR1	0.31973	0.25962	63
SWIR2	0.031	0.204	1
SWIR3	NaN	NaN	0

Table 21: Geometric statistics of PROBAV_L1A_20220722_064306_2_V101

The figure below shows the distortions plots (across, along track) for all spectral bands.

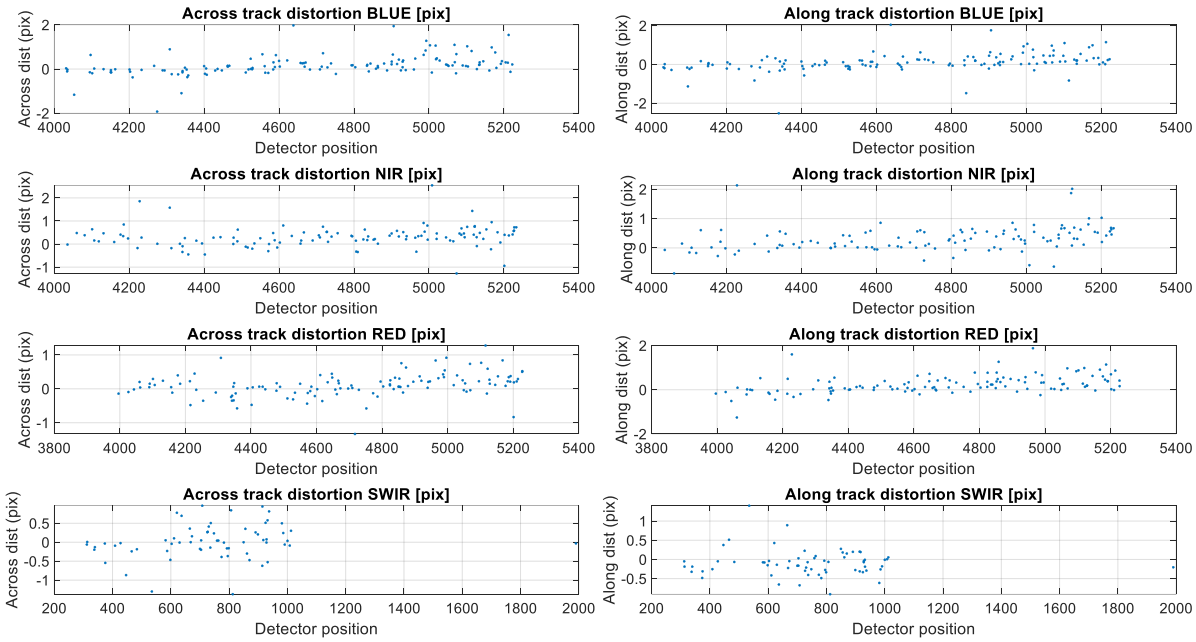

Figure 58: Distortion plots of PROBAV_L1A_20220722_064306_2_V101

The figure below shows the along track distortion in function of the across track distortion in pixels for all spectral bands.

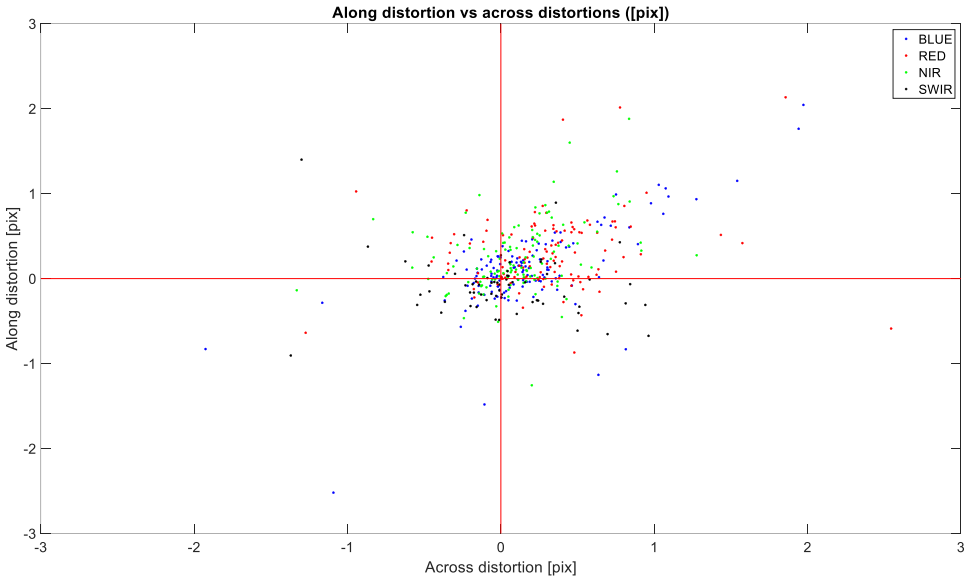

Figure 59: Along track distortion plots of PROBAV_L1A_20220722_064306_2_V101

PROBAV_L1A_20220805_063145_2_V101

The table below shows the geometric statistics:

Band	Mean across distortion (pixel)	Mean along distortion (pixel)	Number of GCPs
BLUE	0.41796	0.48362	545
NIR	0.47801	0.37952	576
RED	0.45343	0.40468	574
SWIR1	0.37578	0.45328	121
SWIR2	0.51009	0.47042	113
SWIR3	0.51475	0.52725	4

Table 22: Geometric statistics of PROBAV_L1A_20220805_063145_2_V101

The figure below shows the distortions plots (across, along track) for all spectral bands.

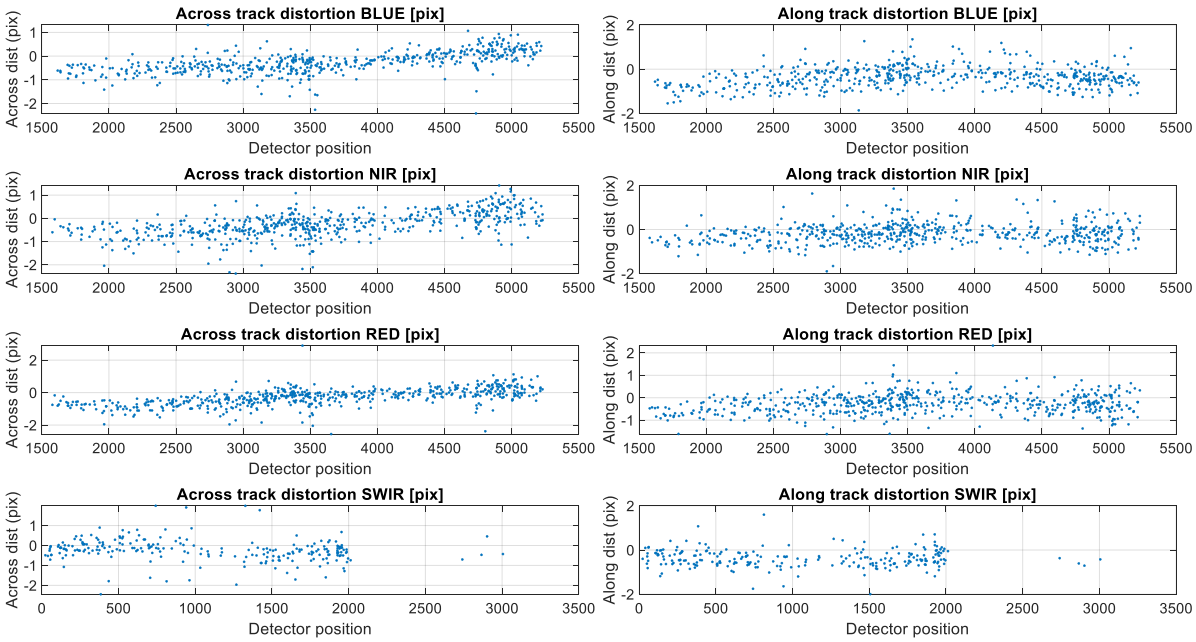

Figure 60: Distortion plots of PROBAV_L1A_20220805_063145_2_V101

The figure below shows the along track distortion in function of the across track distortion in pixels for all spectral bands.

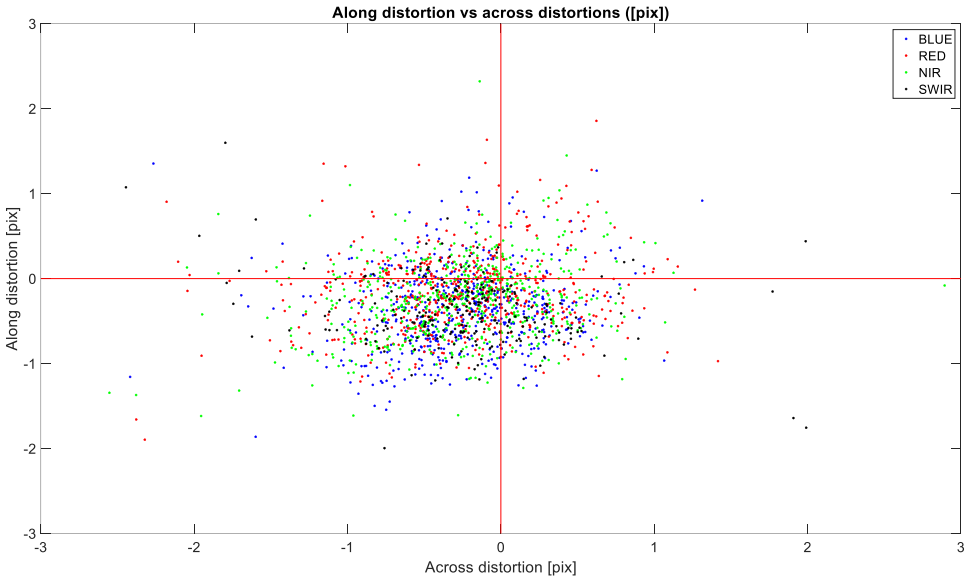

Figure 61: Along track distortion plots of PROBAV_L1A_20220805_063145_2_V101

3.2.1. Summary

The figure below shows the summary for the along/across track distortion in pixels (all acquisition, all spectral bands). Conclusion is that no major geometric anomalies are observed based on Gobabeb acquisitions.

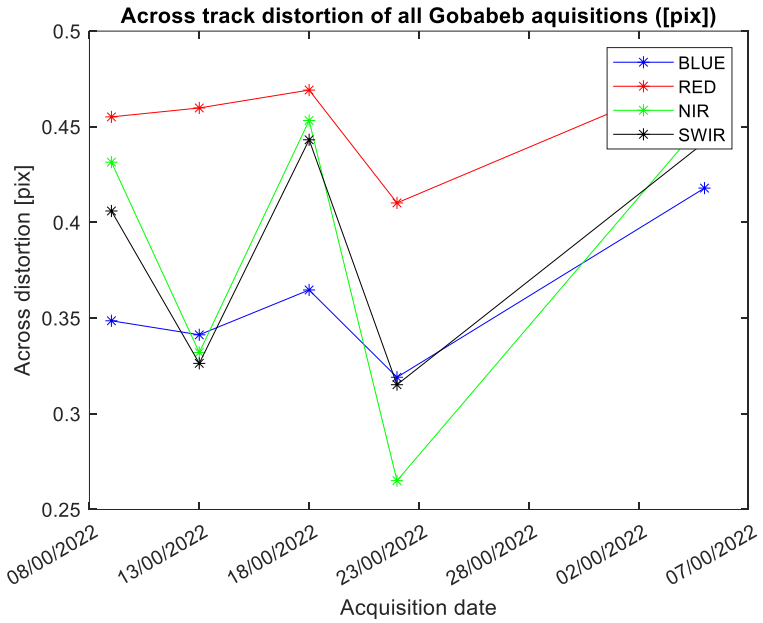

Figure 62: Across track distortions based on Gobabeb acquisitions

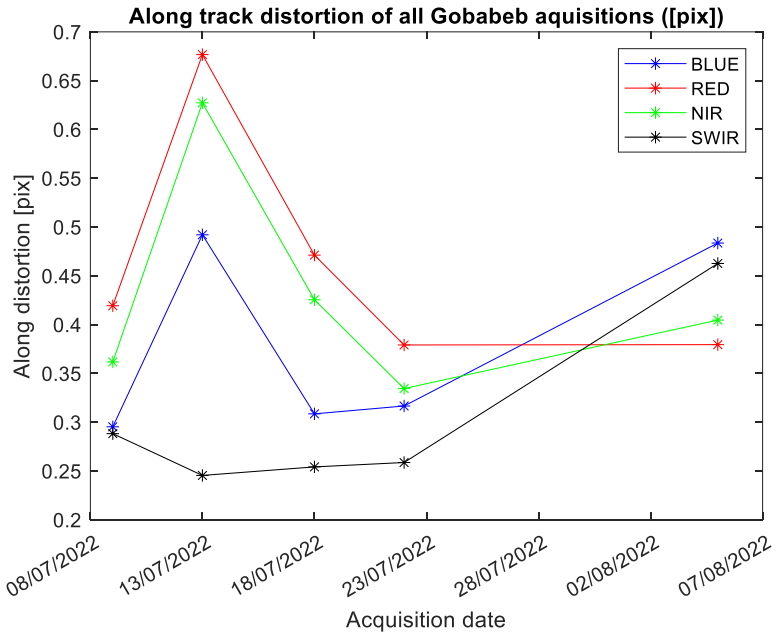

Figure 63: Along track distortions based on Gobabeb acquisitions

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 23: Reference Documents