

Planet Imagery Geometric Assessment

Assessment completed by NASA CSDA
Program Subject Matter Experts:

Alana G. Semple

Bin Tan

Guoqing (Gary) Lin

NASA GSFC Code 619

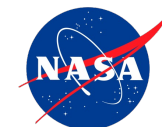
11-13-2023

Introduction



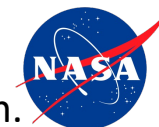
- Geolocation accuracy of Planet's SuperDove (SD) series is evaluated at 25 globally distributed cities.
- Geolocation accuracy of Planet's Dove-R (DR) series is evaluated at 24 globally distributed cities.
- Band-to-Band Registration (BBR) for the SuperDove series is assessed for all bands against Red band.
- Resolution performance is assessed for 6 SuperDove series sensors, 4 of which are assessed both soon after launch and 1+ years after launch.
- A similarly extensive assessment of the Dove-R series is in progress.
- See accompanying document for more details of our SuperDove assessment ([LINK TO DOCUMENT?](#)).

Relative Geolocation Accuracy Assessment Methods



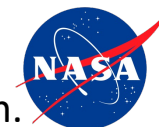
- Planet (PS) SuperDove and Dove-R imagery are assessed for relative geolocation accuracy with WorldView (WV) imagery as the reference dataset. Red bands for both are assessed.
- Assessment is performed globally over cloud free images in likely best case scenario locations (i.e. cities or airports with low buildings and minimal tree cover).
- Images pairs (PS & WV) are split into subset image 'chips' and the offsets between them determined by which offsets give the best Pearson Cross Correlation.
- Chip offset results are filtered based on a match quality metric, and overall image offsets determined based on the high-quality valid matches.
- Reference geolocation uncertainties include those from our reference WV imagery and our orthorectification of it with the 30 m SRTM DEM
- This method is used for our BBR assessment on SuperDove (SD) images, with the corresponding SD Red band as the reference image.

Super Dove Relative Geolocation Accuracy



- Table shows geolocation accuracy of PS Dove-R images relative to a single WV image at each location. (*) mark locations with less certainty in the reference image. **CE90-demean example on slide 6.**

A City Within:	# of Images	# of Valid Matches	X Offset (m)	Y Offset (m)	X StdDev (m)	Y StdDev (m)	X RMSE (m)	Y RMSE (m)	CE90 (m)	CE90-demean (m)
Massachusetts	14	3683	1.3	-6.1	3.0	3.8	3.3	7.1	4.3	2.0
California	11	2257	-2.2	0.3	1.7	1.8	2.8	1.9	3.5	2.3
New Mexico	20	6072	-.4	-0.3	1.9	1.5	1.9	1.5	3.2	3.2
Canada*	6	517	1.7	2.0	2.0	3.2	2.4	3.7	6.0	5.2
Mexico	5	4361	2.0	1.0	1.5	1.4	2.5	1.7	4.5	3.1
Ecuador	6	408	-5.6	-7.6	1.6	2.3	5.8	7.9	11.3	2.6
Brazil	6	6848	-.9	3.3	1.0	1.6	1.3	3.7	5.1	2.6
Chile	5	1023	-4.6	3.8	1.2	1.6	4.8	4.2	7.6	2.6
Argentina	7	1851	-2.5	-5.4	1.7	1.5	3.0	5.6	7.9	3.1
England	6	2727	-3.7	12.8	1.9	2.8	4.1	13.1	16.6	4.6
Ireland	5	2668	-1.1	10.3	1.4	1.5	1.8	10.4	12.3	3.0
Sicily	5	2182	-5.8	10.4	4.3	5.1	7.2	11.6	15.7	5.0
Turkey*	9	2901	-22.0	12.2	2.4	1.9	22.1	12.3	28.1	4.5
Morocco	5	1182	4.3	2.0	5.0	4.2	6.6	4.6	7.0	2.7
Angola	6	4292	3.8	0.4	0.8	1.5	3.9	1.6	5.1	2.6
Somalia	5	5244	-1.2	1.0	1.3	1.2	1.7	1.5	3.3	2.6
South Africa	6	4597	-6.2	0.1	1.6	1.2	6.4	1.2	8.2	2.7
Cairns	6	2758	1.7	-0.3	3.0	3.7	3.4	3.7	6.0	5.0
Melbourne	6	2485	-10.1	9.8	1.0	1.7	10.1	10.0	15.2	2.0
Perth	6	3387	-7.6	-7.5	1.8	1.6	7.8	7.6	13.2	3.6
Baoshan	7	2920	-.9	-1.0	2.5	2.9	2.6	3.1	4.9	4.4
Hohhot	5	1569	-9.4	-1.4	2.0	1.6	9.6	2.1	11.7	3.2
Japan	6	4434	5.0	-7.2	1.2	1.8	5.1	7.4	11.1	3.3
Russia*	6	1463	4.6	3.3	1.9	1.8	5.0	3.7	7.3	2.5
Singapore	6	4159	5.5	4.4	6.4	6.5	8.4	7.9	14.3	9.2
Global	175	75988	-1.7	1.4	6.3	6.1	6.5	6.3	13.8	3.8



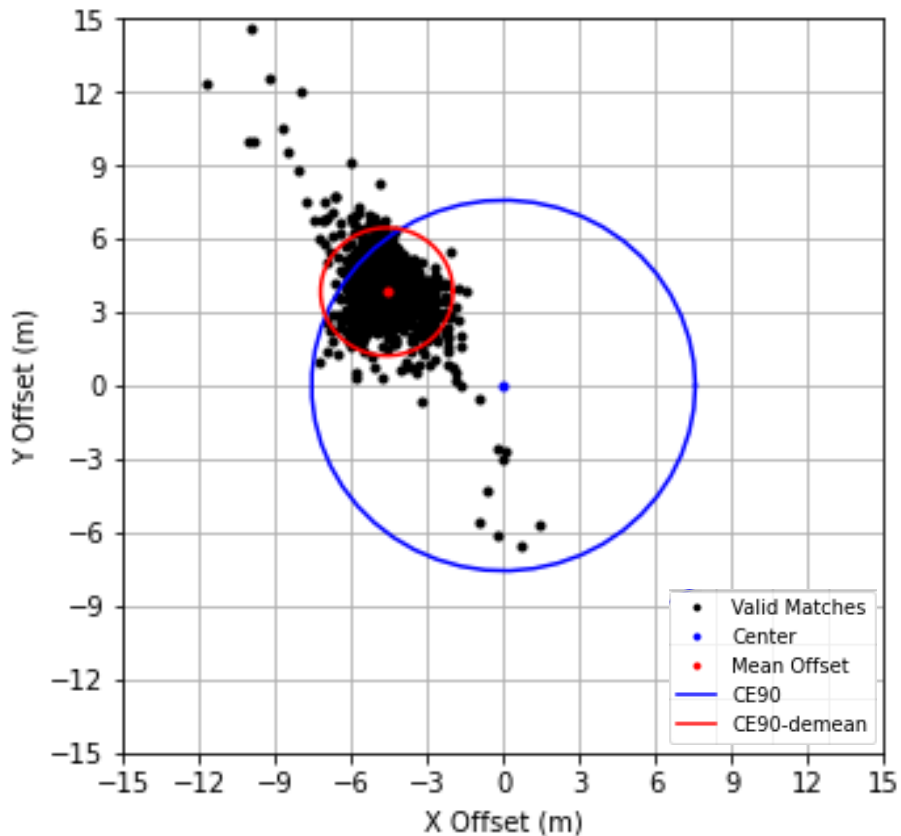
Dove-R Relative Geolocation Accuracy

- Table shows geolocation accuracy of PS Dove-R images relative to a single WV image at each location. (*) mark locations with less certainty in the reference image. **CE90-demean example on slide 6.**

A City Within:	# of DR Images	# of Valid Matches	X Mean (m)	Y Mean (m)	X StdDev (m)	Y StdDev (m)	X RMSE (m)	Y RMSE (m)	CE90 (m)	CE90-demean (m)
California	12	11548	-1.3	-.2	1.0	1.0	1.6	1.0	2.6	2.0
Massachusetts	11	1999	1.4	-6.4	2.9	2.7	3.2	7.0	8.7	2.8
Canada*	6	2748	.8	3.7	1.1	1.8	1.4	4.1	5.2	3.1
Mexico	6	3877	2.0	.5	1.2	.9	2.3	1.0	3.5	2.0
Ecuador	5	1781	-11.8	-2.3	3.3	1.3	12.2	2.6	15.3	5.3
Brazil	6	7187	-1.1	3.8	.6	1.1	1.2	4.0	5.2	1.8
Chile	4	575	-6.1	3.6	1.3	2.6	6.3	4.5	9.3	4.4
Argentina	5	2635	-2.9	-5.2	1.2	.8	3.1	5.3	7.2	2.2
England	11	5188	-2.7	10.8	1.7	4.1	3.2	11.5	14.6	7.2
Ireland	5	4587	-.8	9.8	1.1	1.4	1.4	9.9	11.4	2.5
Sicily	5	6920	-6.1	11.0	1.5	2.2	6.3	11.3	15.1	3.5
Turkey*	9	8168	-17.9	11.5	1.6	1.9	18.0	11.6	23.2	3.7
Morocco	5	2935	4.4	1.4	2.1	1.9	4.9	2.3	6.0	2.3
Angola	6	2520	4.0	.5	2.0	1.8	4.4	1.9	5.2	2.4
Somalia	7	1451	-1.9	.6	4.8	5.2	5.2	5.2	4.5	3.1
South Africa	6	4984	-6.1	-.5	1.4	1.2	6.3	1.2	8.0	2.7
Cairns	6	1190	2.0	-.5	2.5	3.8	3.2	3.8	6.6	5.2
Melbourne	5	2062	-10.3	9.5	2.0	1.9	10.5	9.6	15.1	1.8
Perth	6	2091	-7.8	13.1	2.3	.7	8.1	13.1	17.0	3.7
Egypt	6	4486	-.6	8.5	2.0	2.4	2.1	8.8	10.7	2.8
Baoshan	6	3338	-1.2	-1.6	1.2	1.8	1.7	2.4	4.0	3.0
Hohhot	7	2741	-8.7	-2.0	1.7	2.9	8.9	3.6	10.8	3.7
Japan	8	4282	5.0	-7.7	1.1	2.0	5.2	7.9	11.5	3.2
Russia*	5	1529	4.7	3.0	2.2	2.0	5.2	3.7	7.9	3.3
Total Data:	158	90822	-3.2	3.6	6.2	6.3	7.0	7.3	16.5	3.2

SuperDove Chile Site: CE90 & CE90-Demean

Chile SD CE90 vs CE90-demean



CE90

- CE90 relative to WV reference image.
- CE90 = 7.6 m

CE90-demean

- Definition: CE90-demean, the CE90 with the offset bias of reference image removed. Assuming the bias is wholly contributed from the reference image.
- CE90demean = 2.6 m

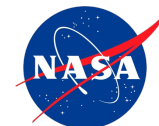
SuperDove BBR

Band vs. Red	# of Valid Matches	Mean X Offset (m)	Mean Y Offset (m)	Mean r_i (m)	CE90(r_i) (m)
Costal Blue	79726	-0.01	-0.16	0.69	1.26
Blue	81598	0.05	0.14	0.52	1.01
Green I	94215	0.00	0.03	0.44	0.82
Green	109539	-0.01	0.00	0.40	0.73
Yellow	125743	0.00	-0.02	0.39	0.68
Red Edge	101528	-0.01	-0.03	0.50	0.93
NIR	41913	0.08	-0.04	1.13	2.36

$$r_i = \sqrt{x_i^2 + y_i^2}$$

- x_i are the EW offsets for each valid chip match relative to red band
- y_i are the NS offsets for each valid chip match relative to red band
- r_i is the radial offset for each valid chip match

- SuperDove Band-to-Band Registration (BBR) is performed with the Red band as reference.
- Note that as the spectral band moves away from Red, the number of matches decreases.
- BBR is sub-pixel for all bands and increases in offset as the spectral bands move away from Red. All offsets are much smaller than footprint size.
- Best performing bands are Yellow and Green with mean radial offset of 0.39 m and 0.40 m, respectively.
- Band farthest offset is NIR with a mean radial offset of 1.13 m.
- This assessment was performed with their reprocessed archive data.



Assess SuperDove Spatial Resolution

- CalVal site in India
- 70 m squares + 10 m color and B/W squares

- Extract raw pixels along black/white (B/W) transition
- Transform from pixel number to distance from B/W transition
- Fit a polynomial to the transformed data to make Edge Spread Function (ESF). Relative Edge Response (RER) is calculated based off the normalized ESF with $RER = \sqrt{ESF_y(0.5) - ESF_y(-0.5)}$
- Calculate derivative of ESF to find Line Spread Function (LSF)
- Fourier transform the LSF to find Modulation Transfer Function (MTF)
- Find Ground Resolved Distance (GRD) where $MTF(1/(2GRD)) = 0.5$

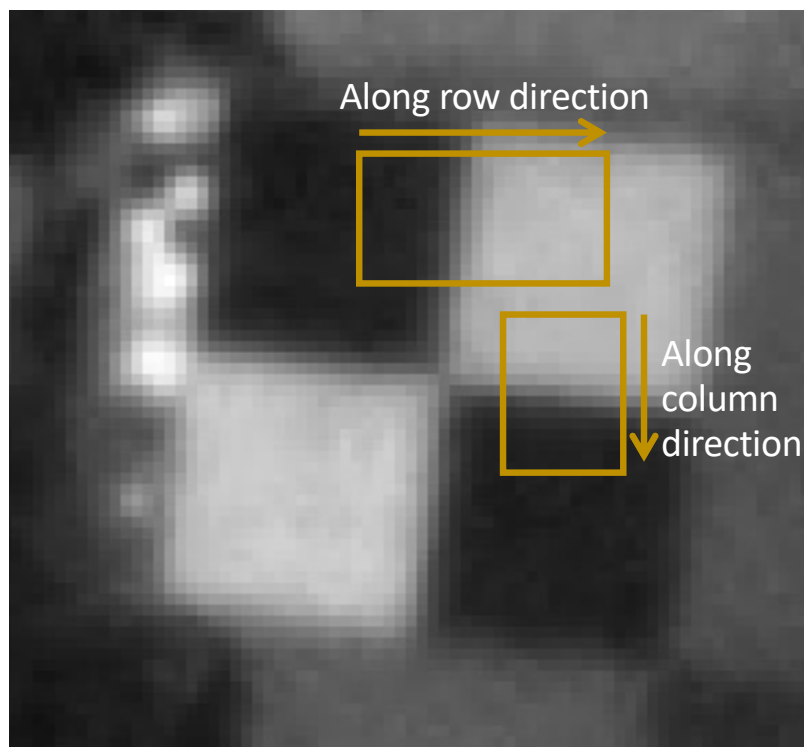
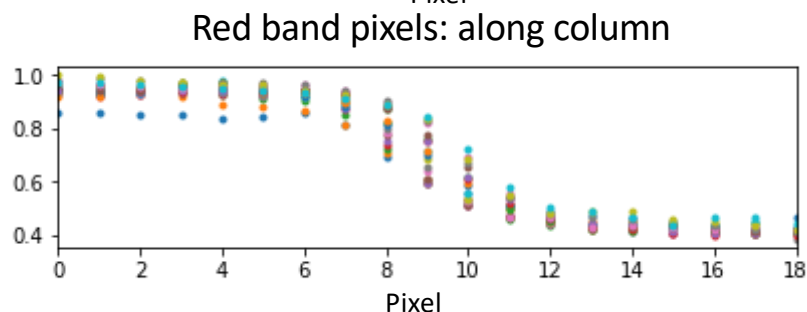
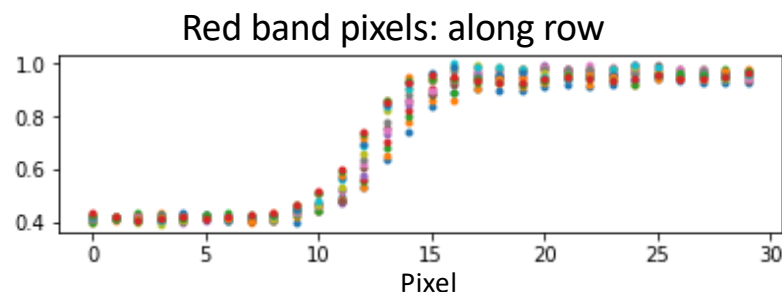


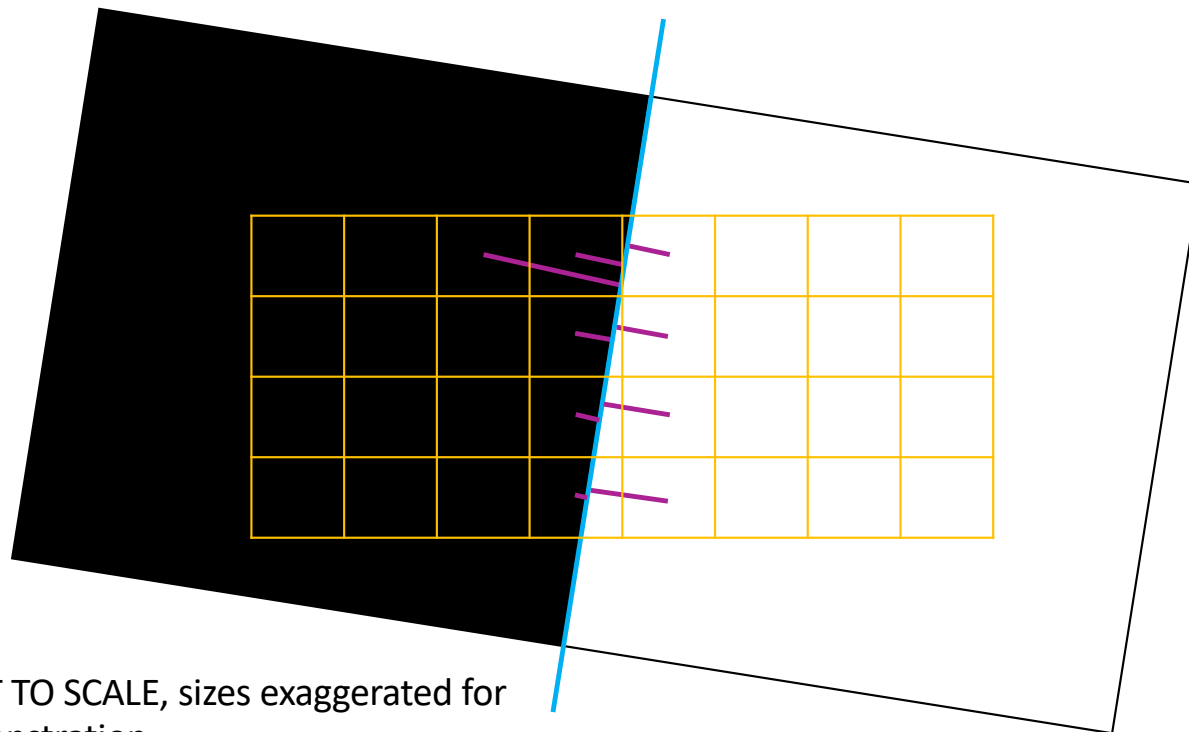
Image provided to NASA by © Planet 2023
Image ID: 20230310_042633_64_24a1
Band: Red



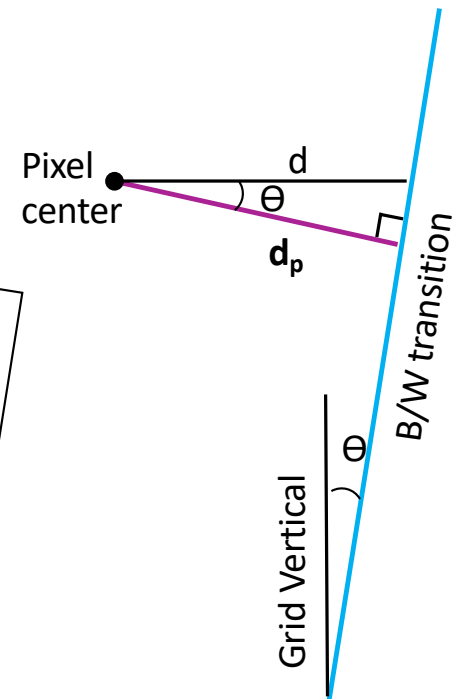
Transform into distance from B/W transition

1. Define a line as the transition from black to white (blue line in diagram)
2. Calculate perpendicular distance from pixel center to blue line (purple lines in diagram, d_p)

$$d_p = d \cdot \cos(\theta)$$

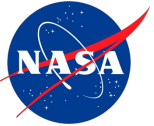


*NOT TO SCALE, sizes exaggerated for demonstration

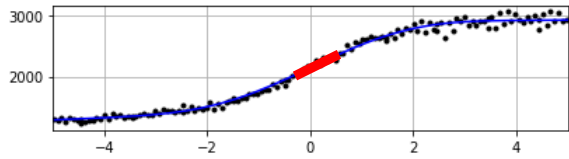


θ = Angle between transition and image grid's vertical

SuperDove RGB Resolution Sensor: 24a1, Along Row

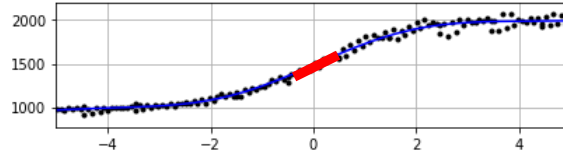


Red Edge Spread Function (ESF)



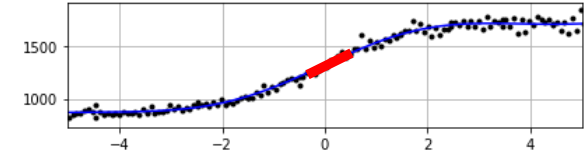
Distance (pixels) **RER = 0.20**

Green I ESF



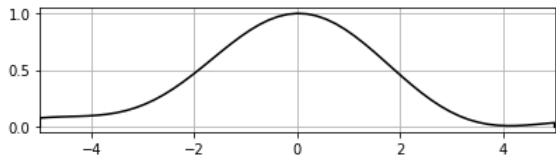
Distance (pixels) **RER = 0.20**

Blue ESF



Distance (pixels) **RER = 0.20**

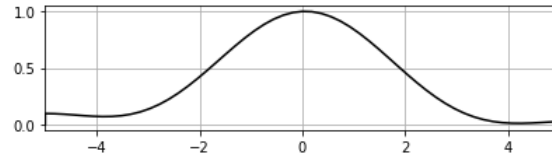
Red Line Spread Function (LSF)



Distance (pixels)

FWHM = 3.8 pixels

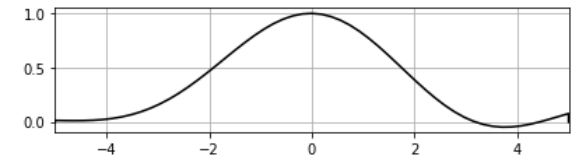
Green I LSF



Distance (pixels)

FWHM = 3.7 pixels

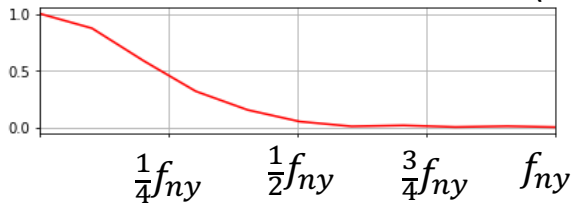
Blue LSF



Distance (pixels)

FWHM = 3.7 pixels

Red Modulation Transfer Function (MTF)

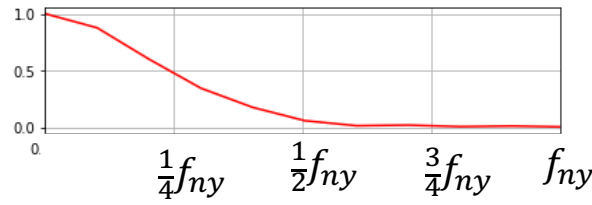


Frequency

MTF @ f_{ny} = 0.004

GRD = 4.0 pixels

Green I MTF

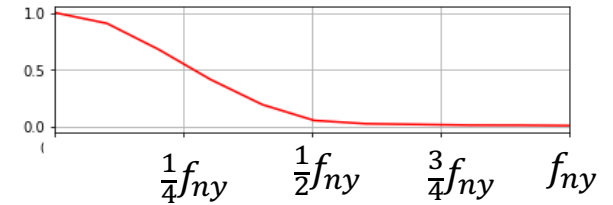


Frequency

MTF @ f_{ny} = 0.007

GRD = 4.0 pixels

Blue MTF

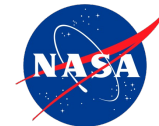


Frequency

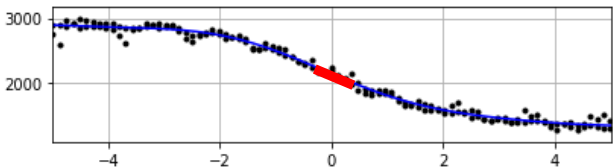
MTF @ f_{ny} = 0.008

GRD = 3.9 pixels₁₀

SuperDove RGB Resolution Sensor: 24a1, Along Column

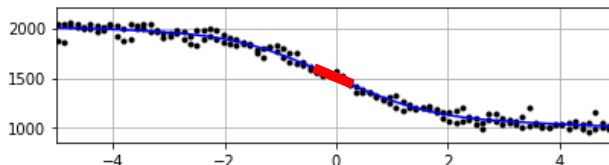


Red Edge Spread Function (ESF)



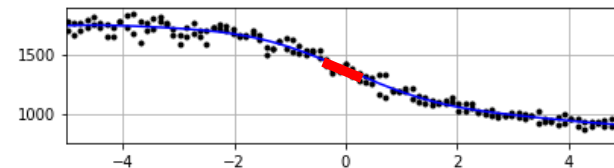
Distance (pixels) **RER = 0.20**

Green I ESF



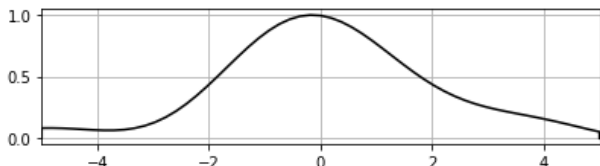
Distance (pixels) **RER = 0.21**

Blue ESF



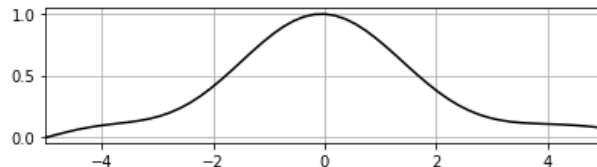
Distance (pixels) **RER = 0.21**

Red Line Spread Function (LSF)



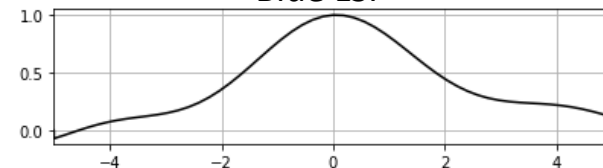
Distance (pixels) **FWHM = 3.6 pixels**

Green I LSF



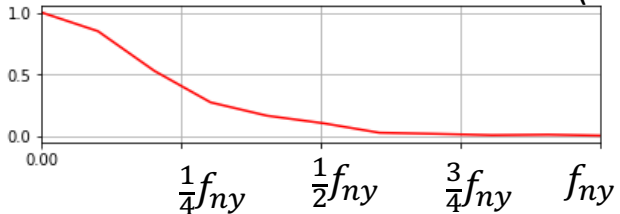
Distance (pixels) **FWHM = 3.4 pixels**

Blue LSF



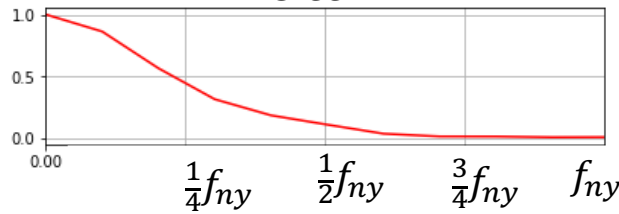
Distance (pixels) **FWHM = 3.4 pixels**

Red Modulation Transfer Function (MTF)



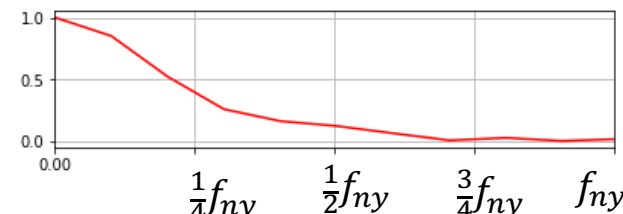
Frequency
MTF @ f_{ny} = 0.005
GRD = 4.3 pixels

Green I MTF



Frequency
MTF @ f_{ny} = 0.011
GRD = 4.1 pixels

Blue MTF



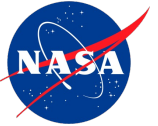
Frequency
MTF @ f_{ny} = 0.020
GRD = 4.3 pixels

SuperDove RGB Resolution: Temporal Changes

Sensor (image date)	Pixel Size (m)	Band	Row Direction				Column Direction			
			RER	FWHM (pix)	GRD (pix)	MTF @ny	RER	FWHM (pix)	GRD (pix)	MTF @ny
24b0 (06/23) Y	3.0	R	0.29	2.57	4.00	0.004	0.29	2.59	4.10	0.004
		G	0.30	2.67	3.90	0.049	0.30	2.70	4.00	0.031
		B	0.30	2.69	3.75	0.040	0.30	2.71	3.75	0.028
2478 (03/22) X	3.0	R	0.23	3.14	4.20	0.007	0.23	3.20	4.20	0.008
		G	0.23	3.10	4.20	0.008	0.23	3.11	4.00	0.010
		B	0.24	3.00	4.00	0.007	0.24	3.05	4.00	0.009
2478 (03/23) X	3.0	R	0.24	3.06	4.20	0.011	0.23	3.10	4.20	0.010
		G	0.22	3.24	4.20	0.011	0.22	3.25	4.20	0.011
		B	0.24	2.93	4.00	0.006	0.24	3.02	4.00	0.005
2420 (03/21) S	3.0	R	0.22	3.21	4.20	0.007	0.22	3.25	4.20	0.007
		G	0.20	3.53	4.33	0.008	0.20	3.55	4.33	0.007
		B	0.23	3.21	4.10	0.010	0.22	3.23	4.20	0.009
2420 (03/23) S	3.0	R	0.24	2.84	4.20	0.012	0.24	2.85	4.33	0.010
		G	0.20	3.55	4.33	0.010	0.20	3.57	4.33	0.008
		B	0.24	2.93	4.20	0.013	0.24	2.93	4.33	0.009
2254 (10/20) V	3.0	R	0.14	4.21	4.50	0.002	0.14	4.21	4.50	0.005
		G	0.13	4.20	4.50	0.006	0.14	4.21	4.50	0.006
		B	0.13	4.15	4.50	0.007	0.13	4.17	4.50	0.010
2254 (10/22) V	3.0	R	0.20	3.33	4.20	0.009	0.20	3.36	4.20	0.009
		G	0.21	3.30	4.20	0.012	0.21	3.32	4.20	0.009
		B	0.21	3.31	4.10	0.008	0.21	3.32	4.10	0.010
2231 (09/20) P	3.0	R	0.20	3.87	4.00	0.010	0.19	3.90	4.00	0.009
		G	0.20	3.60	4.00	0.008	0.20	3.61	4.10	0.008
		B	0.20	3.86	4.00	0.008	0.20	3.88	4.00	0.002
2231 (08/22) P	3.0	R	0.22	3.19	4.10	0.005	0.22	3.19	4.10	0.006
		G	0.23	3.14	4.00	0.004	0.23	3.15	4.00	0.005
		B	0.23	3.16	4.00	0.007	0.23	3.16	4.00	0.007
Mean (near Launch)	3.0	R	0.22	3.40	4.18	0.006	0.21	3.43	4.20	0.007
G		0.21	3.42	4.19	0.016	0.21	3.44	4.19	0.012	
B		0.22	3.38	4.07	0.014	0.22	3.41	4.09	0.012	
Mean (After 1+ Years)	3.0	R	0.23	3.18	4.18	0.009	0.22	3.20	4.21	0.009
G		0.22	3.36	4.18	0.009	0.22	3.37	4.18	0.008	
B		0.23	3.11	4.08	0.009	0.23	3.13	4.11	0.008	

- Planet has launched 5 'Flocks' of SD series satellites.
 - Flock4Y – 1/2023
 - Flock4X – 1/2022
 - Flock4S – 1/2021
 - Flock4V – 9/2020
 - Flock4P – 11/2019
- We assessed RGB resolution for 1 sensor of Flocks P – X at two times;
 - 1st: soon after launch
 - 2nd: 1+ yrs after launch
- Generally, SD performance improves after launch

Summary



- PS self-consistency (CE90-demean) is internally consistent with less than 3 pixels (9m) of offset at all sites for both SuperDove and Dove-R. Globally, SD self-consistency is 3.8 m and DR self-consistency is 3.2 m.
- PS relative to WV geolocation accuracy varies by location. SuperDove varies from 3.2 m – 28.1 m CE90, Dove-R varies from 2.6 m CE90 – 23.2 m CE90.
- SD BBR is sub-pixel for all bands when compared to Red band, and offsets are much smaller than sensor footprint size. Mean radial offsets vary from 0.39 m – 1.13 m.
- SD sensor performance (RER, FWHM, GRD) improves with time. Average performance in both row and column direction after 1+yrs in orbit is RER = 0.22, FWHM = 3.23 pixels (9.7 m), GRD = 4.15 pixels (12.5 m).
- A similarly extensive analysis of DR series is in progress.

Appendix – SuperDove Image IDs

Angola	20220614_091642_30_2414	California	20220102_173945_81_241f	Melbourne	20230106_231854_93_2423	Sicily	20220728_084908_71_2420
Angola	20220615_091655_93_2403	California	20220314_180751_22_2484	Melbourne	20230108_235759_99_2492	Sicily	20220826_093854_03_2403
Angola	20221120_090504_69_248f	California	20220318_173912_93_2458	Melbourne	20230113_232237_45_2439	Sicily	20220920_090907_39_2251
Angola	20221231_090256_29_2488	California	20220318_173915_23_2458	Melbourne	20230124_235515_91_2474	Sicily	20221009_092155_59_247c
Angola	20230117_082359_56_2449	California	20220321_182556_66_2274	Melbourne	20230209_235646_09_2495	Sicily	20221102_084454_96_2421
Angola	20230212_082900_15_245c	California	20220322_173527_69_2436	Melbourne	20230214_232059_65_2430	Singapore	20220115_023613_93_241d
Argentina	20220906_135826_07_248e	California	20220323_180829_98_2479	Mexico	20220812_164557_68_248f	Singapore	20220305_023515_15_2442
Argentina	20220921_135935_89_24a3	California	20220325_175254_94_2251	Mexico	20221012_164427_41_24a4	Singapore	20220330_023353_67_2460
Argentina	20221006_132013_07_2420	California	20220327_173324_59_2455	Mexico	20221115_160955_84_2449	Singapore	20220608_023038_30_2423
Argentina	20221016_141519_61_2426	California	20220327_173326_89_2455	Mexico	20221130_161039_16_2464	Singapore	20220608_023040_60_2423
Argentina	20221107_135943_29_2470	California	20220327_182311_48_240c	Mexico	20221206_165334_75_2416	Singapore	20220626_030343_20_249a
Argentina	20221202_131553_16_2445	Canada	20220818_180159_98_248e	Morocco	20220119_103512_22_2276	Somalia	20230103_062753_37_2421
Argentina	20221204_135655_60_24a4	Canada	20220831_174603_38_2251	Morocco	20220701_110523_37_2405	Somalia	20230117_070122_69_2481
Baoshan	20230416_025814_60_2463	Canada	20220912_175827_76_2461	Morocco	20220712_110438_64_2426	Somalia	20230127_062533_71_242d
Baoshan	20230419_034202_10_2495	Canada	20220928_175725_94_2231	Morocco	20220801_104927_16_2485	Somalia	20230209_071657_90_2402
Baoshan	20230419_034204_30_2495	Canada	20221008_180125_31_24a5	Morocco	20220818_105201_85_2481	Somalia	20230214_065921_43_249b
Baoshan	20230507_030934_45_242e	Canada	20221031_173210_36_2427	New Mexico	20210521_170216_43_2435	South Africa	20221117_082550_90_248f
Baoshan	20230507_030936_73_242e	Chile	20220227_135324_78_242b	New Mexico	20210721_175133_06_2405	South Africa	20221204_075225_33_2432
Baoshan	20230508_030846_05_24c9	Chile	20220303_144415_55_2413	New Mexico	20210821_175205_10_240c	South Africa	20221221_084024_39_2414
Baoshan	20230521_033404_20_2276	Chile	20220309_135743_19_245c	New Mexico	20210918_170207_40_2460	South Africa	20230108_082340_59_2488
Boston	20211105_144343_64_241d	Chile	20220315_144314_88_241c	New Mexico	20211018_170903_24_2262	South Africa	20230130_082603_51_2461
Boston	20211217_153204_71_2413	Chile	20220406_142800_60_2446	New Mexico	20211120_165918_53_2448	South Africa	20230213_074524_57_2460
Boston	20220116_144110_64_2429	Ecuador	20211224_145421_31_241d	New Mexico	20211220_170206_79_241e	Turkey	20220103_074152_64_2463
Boston	20220211_144123_01_2464	Ecuador	20220430_145139_27_2427	New Mexico	20220121_165951_74_241e	Turkey	20220103_074548_15_245d
Boston	20220220_143956_50_2428	Ecuador	20220509_145043_12_241f	New Mexico	20220220_165722_46_2463	Turkey	20220327_081557_40_2478
Boston	20220220_143958_98_2428	Ecuador	20220726_152125_71_2489	New Mexico	20220325_165623_73_2436	Turkey	20220620_073855_91_2434
Boston	20220313_144011_83_2435	Ecuador	20220820_144826_61_2430	New Mexico	20220420_174134_74_2414	Turkey	20220713_081123_06_2481
Boston	20220313_144014_31_2435	Ecuador	20221005_144601_04_2442	New Mexico	20220520_172717_50_247b	Turkey	20220721_082556_10_227a
Boston	20220418_143755_97_241d	England	20220415_104155_70_2446	New Mexico	20220601_165617_69_2434	Turkey	20220727_080737_08_222f
Boston	20220418_151350_69_248b	England	20220430_101315_25_2212	New Mexico	20220711_165613_72_2429	Turkey	20220730_073957_28_241f
Boston	20220505_151336_92_2475	England	20220711_104046_58_2489	New Mexico	20220812_165207_99_2429	Turkey	20220801_073724_55_2442
Boston	20220605_151232_63_2481	England	20220719_105448_62_2403	New Mexico	20220906_165015_66_2459		
Boston	20220713_150926_11_247e	England	20220812_100725_04_2458	New Mexico	20221014_172421_42_247f		
Boston	20220713_150928_40_247e	England	20220814_103737_39_2446	New Mexico	20221109_164932_90_2455		
Boston	20220806_144108_34_2432	Hohhot	20230507_023004_46_24bc	New Mexico	20221219_165519_34_242d		
Boston	20220908_143645_97_2455	Hohhot	20230508_030650_98_227a	New Mexico	20230112_165441_23_245c		
Boston	20221008_151304_57_247a	Hohhot	20230515_023009_52_24af	Russia	20230422_051520_05_2481		
Boston	20221104_143732_55_2432	Hohhot	20230517_022426_06_241d	Russia	20230504_051659_13_2479		
Boston	20221213_152633_03_2413	Hohhot	20230518_030209_16_2446	Russia	20230510_043913_72_24b6		
Brazil	20220924_124349_64_249c	Ireland	20220421_110555_09_2478	Russia	20230519_044131_33_2439		
Brazil	20221011_120749_62_242b	Ireland	20220620_110736_45_247a	Russia	20230520_051918_30_2489		
Brazil	20221108_124503_22_249d	Ireland	20220829_110915_90_2492	Russia	20230521_051552_39_247a		
Brazil	20221110_120729_31_2459	Ireland	20221013_103101_99_2453	Perth	20221219_015630_57_2446		
Brazil	20221118_124518_22_2486	Ireland	20221022_103358_26_2427	Perth	20230101_012048_43_2430		
Brazil	20221129_120859_02_2465	Japan	20230425_010304_31_2488	Perth	20230113_012250_57_2436		
Cairns	20221022_000732_39_2477	Japan	20230502_003624_72_24cc	Perth	20230129_015706_14_2482		
Cairns	20221115_002353_99_240c	Japan	20230514_003139_48_24b9	Perth	20230205_015645_96_24a5		
Cairns	20221206_233443_53_241e	Japan	20230516_010706_16_247a	Perth	20230212_011900_62_2442		
Cairns	20221207_000941_97_247c	Japan	20230516_010708_37_247a				
Cairns	20221208_233511_27_242d	Japan	20230520_005957_42_2276				
Cairns	20230124_233228_65_2449						

Appendix – Dove-R Image IDs

Angola	20210530_095104_75_105a	California	20210328_185011_20_1059	Ireland	20210307_114651_75_105d	Singapore	20210302_034803_70_1057
Angola	20210926_095718_66_105d	California	20210428_180506_83_106a	Ireland	20210330_115219_18_105a	Singapore	20210526_035254_74_105a
Angola	20220117_100107_23_1057	California	20210428_180508_38_106a	Ireland	20210417_102336_72_1067	Singapore	20210708_033313_25_106a
Angola	20220212_100349_67_1057	California	20210503_180429_99_106c	Ireland	20210717_101708_79_106d	Singapore	20220128_040350_68_1057
Angola	20220318_100343_74_1066	California	20210503_180431_52_106c	Ireland	20210824_115511_20_105d	Singapore	20220128_040352_18_1057
Angola	20220416_100726_69_1061	California	20210614_180426_60_106d	Japan	20210601_015129_68_105e	Singapore	20220330_030358_75_105c
Argentina	20210509_155251_49_106e	California	20210728_185802_20_105d	Japan	20210601_015131_68_105e	Somalia	20210130_073753_40_1069
Argentina	20210818_154414_19_1067	California	20210825_185834_67_1061	Japan	20210719_015147_24_1057	Somalia	20210227_074305_74_105a
Argentina	20210907_145240_23_105d	California	20210914_190209_68_1060	Japan	20210720_003616_73_106c	Somalia	20210305_071322_55_105c
Argentina	20211130_145730_26_1058	California	20211014_190008_17_1066	Japan	20210720_003618_73_106c	Somalia	20210412_073234_09_1067
Argentina	20220222_153115_66_1063	California	20211216_175056_68_106c	Japan	20210731_011256_01_105c	Somalia	20210901_074940_73_1061
Baoshan	20210125_041856_11_1060	Canada	20210612_171559_49_1063	Japan	20210731_011258_49_105c	Somalia	20220113_075816_69_1066
Baoshan	20210126_041858_28_1064	Canada	20210613_171157_63_106e	Japan	20210915_003558_82_106a	Somalia	20220205_075951_24_105e
Baoshan	20210126_041859_79_1064	Canada	20210728_185218_70_105d	Melbourne	20210709_004751_21_1057	South Africa	20211028_093121_71_106a
Baoshan	20210127_041929_48_1059	Canada	20210818_170616_25_106e	Melbourne	20210830_110002_32_1067	South Africa	20211217_092202_74_1057
Baoshan	20210206_034730_22_1063	Canada	20210907_185639_68_105a	Melbourne	20211003_004918_23_1057	South Africa	20220121_092508_72_1058
Baoshan	20210209_034732_33_106c	Canada	20211030_190038_69_105a	Melbourne	20220110_005621_18_105d	South Africa	20220205_092307_68_106c
Boston	20210309_152625_60_105c	Ecuador	20190320_164054_19_1063	Melbourne	20220319_005722_33_106a	South Africa	20220325_092316_69_106c
Boston	20210409_145440_44_1065	Ecuador	20200908_161335_58_106b	Mexico	20210719_165623_80_1063	South Africa	20220419_093142_23_1066
Boston	20210507_145136_35_106c	Ecuador	20201022_153753_25_105c	Mexico	20211012_165254_81_106a	Turkey	20201111_085123_67_1057
Boston	20210507_145137_88_106c	Ecuador	20201113_155848_75_1057	Mexico	20211225_164729_16_106c	Turkey	20201204_085218_07_105a
Boston	20210602_145031_69_106c	Ecuador	20210419_155701_06_106c	Mexico	20220127_174450_17_1061	Turkey	20201206_085414_50_105e
Boston	20210602_145033_19_106c	Egypt	20210818_090137_76_1058	Mexico	20220221_174841_24_105e	Turkey	20201220_081056_53_1065
Boston	20220106_151110_58_105c	Egypt	20210906_090425_73_1058	Mexico	20220329_175202_74_105a	Turkey	20211030_074855_69_106c
Boston	20220315_143252_73_1067	Egypt	20211217_075801_24_106c	Morocco	20210816_104134_91_1067	Turkey	20211030_090927_18_105e
Boston	20220315_143254_23_1067	Egypt	20220105_090728_73_1061	Morocco	20210826_114137_17_1064	Turkey	20211117_090745_20_1064
Boston	20220322_161543_17_105d	Egypt	20220118_091048_24_1058	Morocco	20211207_103328_94_106a	Turkey	20211121_090745_73_1061
Boston	20220322_161544_67_105d	Egypt	20220211_075337_76_106a	Morocco	20220113_115014_70_1058	Turkey	20211212_081427_16_105c
Brazil	20210522_134001_99_106e	England	20190826_103638_06_106c	Morocco	20220116_114807_68_1058		
Brazil	20210722_133634_73_106c	England	20190904_105353_82_1058	Novosibirsk	20200708_044014_13_1067		
Brazil	20210824_133803_66_105a	England	20200129_102510_77_1062	Novosibirsk	20200717_054302_34_1057		
Brazil	20210824_133805_66_105a	England	20200730_110942_71_1064	Novosibirsk	20200813_043749_61_106b		
Brazil	20210919_133902_20_1060	England	20201224_111906_70_1057	Novosibirsk	20200921_054740_78_105a		
Brazil	20211002_133021_12_1067	England	20210227_112402_71_1064	Novosibirsk	20200928_043640_11_1063		
Cairns	20201030_002337_59_105c	England	20210722_095340_04_106e	Perth	20211208_025328_25_1058		
Cairns	20210725_005641_70_1064	England	20211021_113350_71_1058	Perth	20220106_025548_69_1067		
Cairns	20210922_010053_76_105d	England	20211107_113541_24_1061	Perth	20220120_025715_77_1061		
Cairns	20211123_004711_05_1065	England	20211125_094955_73_106a	Perth	20220201_025104_73_1065		
Cairns	20211123_004713_10_1065	England	20220308_093934_88_1065	Perth	20220225_025848_75_1057		
Cairns	20211209_001150_46_105c	Hohhot	20201122_033527_68_1060	Perth	20220325_025845_21_1064		
		Hohhot	20201122_033529_68_1060	Sicily	20211114_101903_73_1058		
		Hohhot	20201130_033508_71_1064	Sicily	20211210_085813_54_1065		
		Hohhot	20201204_025101_25_106c	Sicily	20220103_102307_69_105a		
		Hohhot	20201219_031305_18_105c	Sicily	20220218_102342_72_1061		
		Hohhot	20210105_031143_31_105c	Sicily	20220304_102133_23_1061		
		Hohhot	20210201_024548_88_1063				