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ABSOLUTE CALIBRATION OF THE RAPIDEYE CONSTELLATION

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BlackBridge AG

Calcon 2014

OUTLINE



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- The RapidEye Constellation.
- Vicarious Campaigns
- Vicarious Results
- Absolute Update
- Results of the Update
- Validation
- Conclusions



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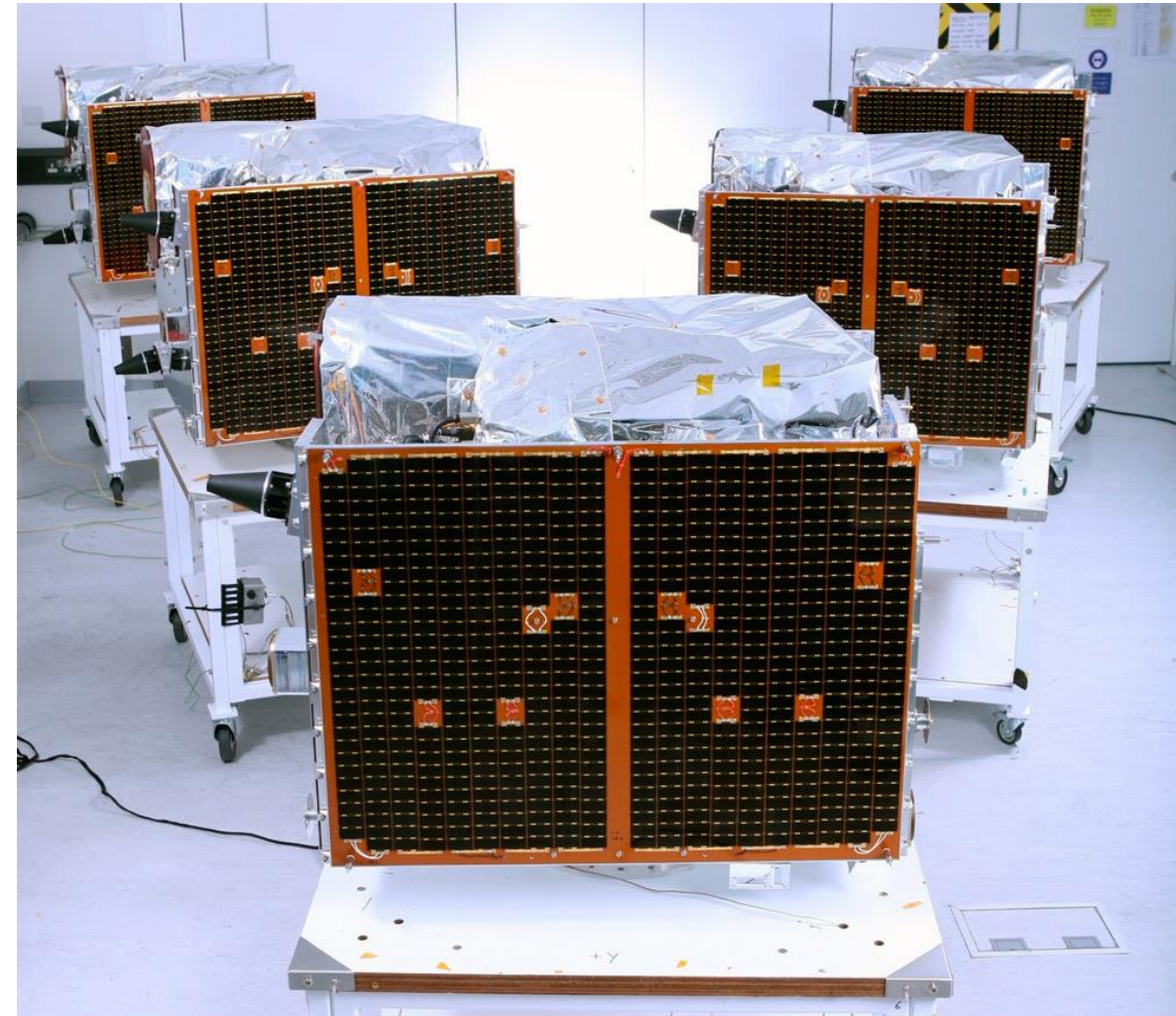
THE RAPIDEYE CONSTELLATION

THE RAPIDEYE CONSTELLATION



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- 5 optical satellites.
- 5 spectral bands: Blue, Green, Red, Red-Edge, NIR.
- 6.5 m GSD, 77km swath width.
- >5 million sq km/day.
- Daily revisit possible!!





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VICARIOUS CAMPAIGNS

PREVIOUS VICARIOUS CAMPAIGNS



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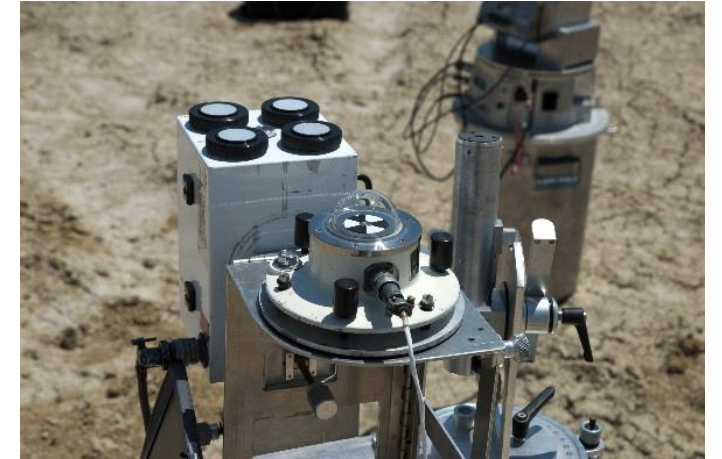
- Several vicarious campaigns have been performed with the University of Arizona and South Dakota State University between 2009-2013.
 - 2009-2010 Railroad Valley and Ivanpah Playa (2 sats., 10 collects)
 - 2011 Railroad Valley (5 sats., 5 collects)
 - 2012 Railroad Valley (5 sats., 25 collects)
 - 2012 Brookings (5 sats., 9 collects)
 - 2013 Railroad Valley (5 sats., 5 collects)

FIELD CAMPAIGNS



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- Field Equipment
 - Sun Photometer
 - Line-of-Sight Photometer
 - Wide Angle Photometer
 - Field Spectrometer



FIELD LOCATIONS



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- Ivanpah Playa
 - Dry Lake Bed
 - Bright
 - Homogeneous



FIELD LOCATIONS



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- Railroad Valley
 - Dry Lake Bed
 - Bright
 - Homogeneous
 - High Elevation



FIELD LOCATIONS



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- Brookings
 - Prairie
 - Dark
 - Easily Accessible





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VICARIOUS RESULTS

IVANPAH AND RAILROAD VALLEY RESULTS



Percent Differences Between Field Measurements and Imagery Mean of All Collects ± Standard Deviation of All Collects

	RE1	RE2	RE3	RE4	RE5
Blue	3.01 ± 1.63	2.1 ± 0.39	1.42 ± 3.48	0.99 ± 2.32	0.59 ± 3.39
Green	4.92 ± 2.51	2.98 ± 0.97	3.38 ± 3.85	1.75 ± 2.03	3.09 ± 4.55
Red	3.93 ± 1.31	2.44 ± 0.63	3.38 ± 1.84	1.65 ± 2.08	1.87 ± 2.65
Red-Edge	3.54 ± 2.23	2.4 ± 0.45	3.05 ± 2.18	3.09 ± 3.57	2.02 ± 3.1
NIR	3.05 ± 1.58	1.52 ± 0.56	2.88 ± 1.76	3.46 ± 2.86	0.61 ± 2.26
Total Collects	6	3	9	10	4

- Imagery and Field Measurements over the Ivanpah and Railroad Valley sites appear to agree quite well with a maximum difference of 4.92%.
- RE2 only had 3 coincident collects with Field Measurements, but the results seem to agree with each other better (less and 1% standard deviation) than with the other sensors.

BROOKINGS RESULTS



Percent Differences Between Field Measurements and Imagery Mean of All Collects ± Standard Deviation of All Collects

	RE1	RE2	RE3	RE4	RE5
Blue	10.3 ± 4.63	15.2 ± 0	13.1 ± 5.16	19.6 ± 0	16.7 ± 2.41
Green	6.77 ± 4.47	13 ± 0	8.76 ± 4.88	22.2 ± 0	17.6 ± 4.7
Red	1.58 ± 4.3	12.2 ± 0	6.67 ± 5.34	19.5 ± 0	11.8 ± 6.47
Red-Edge	-4.1 ± 0.98	0.71 ± 0	-0.6 ± 1.42	1.68 ± 0	3.27 ± 1.18
NIR	-2.3 ± 1.7	-1.3 ± 0	-2.9 ± 1.49	-2.6 ± 0	2.06 ± 2.11
Total Collects	3	1	2	1	2

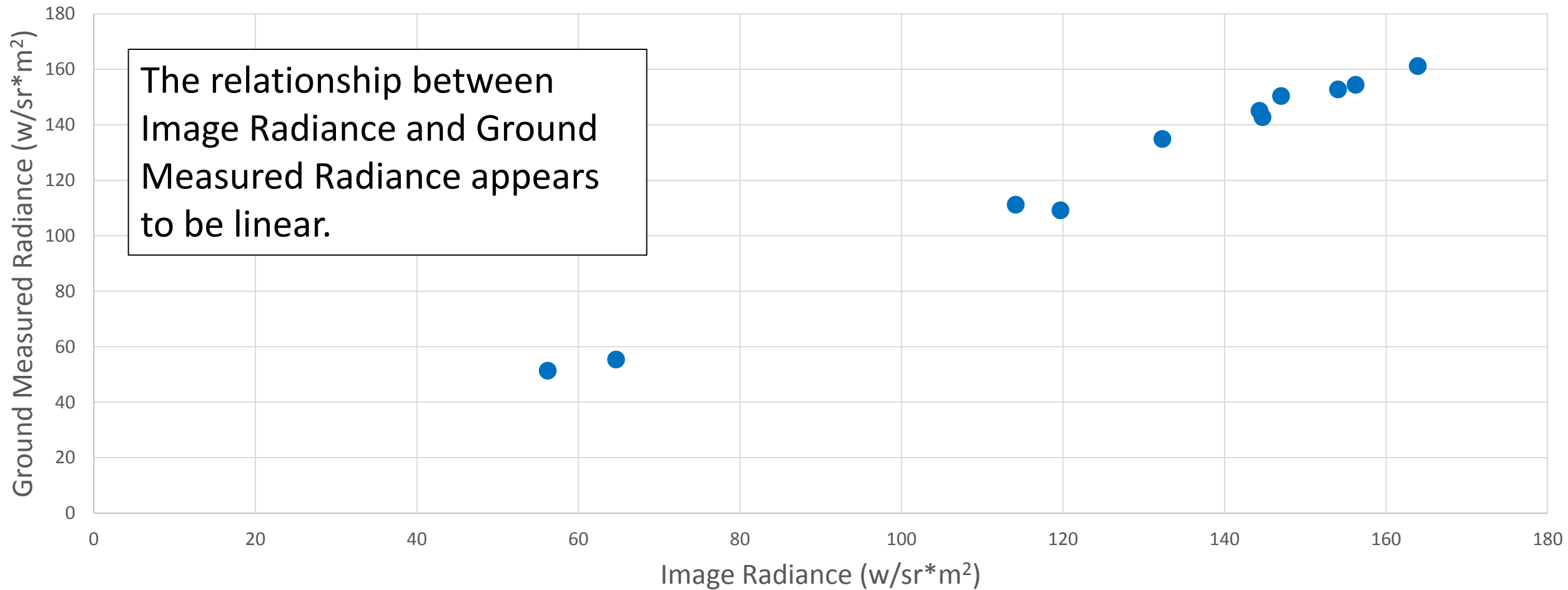
- There were some large differences between the Imagery and Field Measurements of the Brookings site especially in the visible bands.
- Not all sensors behave similarly. RE1 is near or less than 10% in all bands while RE4 is nearly 20% in the visible bands.
- The percent differences over this darker site are also much higher due to the small values used in the calculation.

MEASURED RADIANCE VS IMAGE RADIANCE



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RapidEye 3 Blue Band

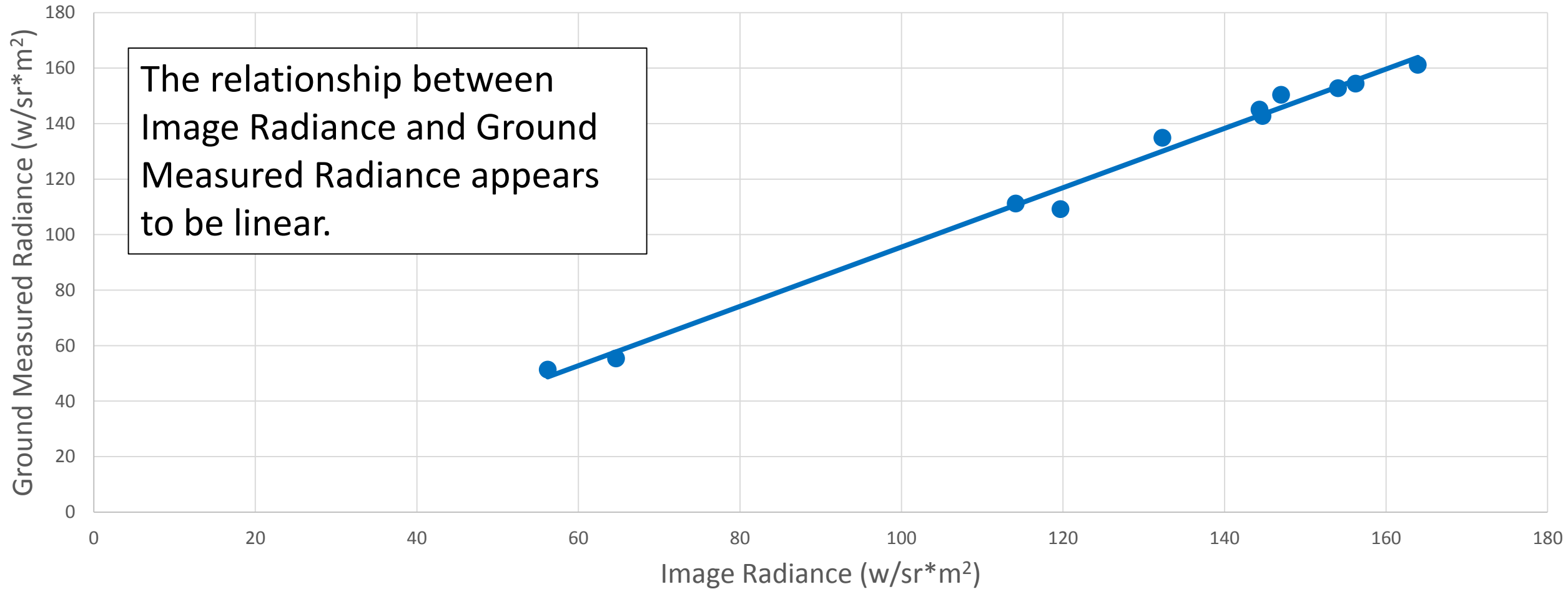


MEASURED RADIANCE VS IMAGE RADIANCE



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RapidEye 3 Blue Band





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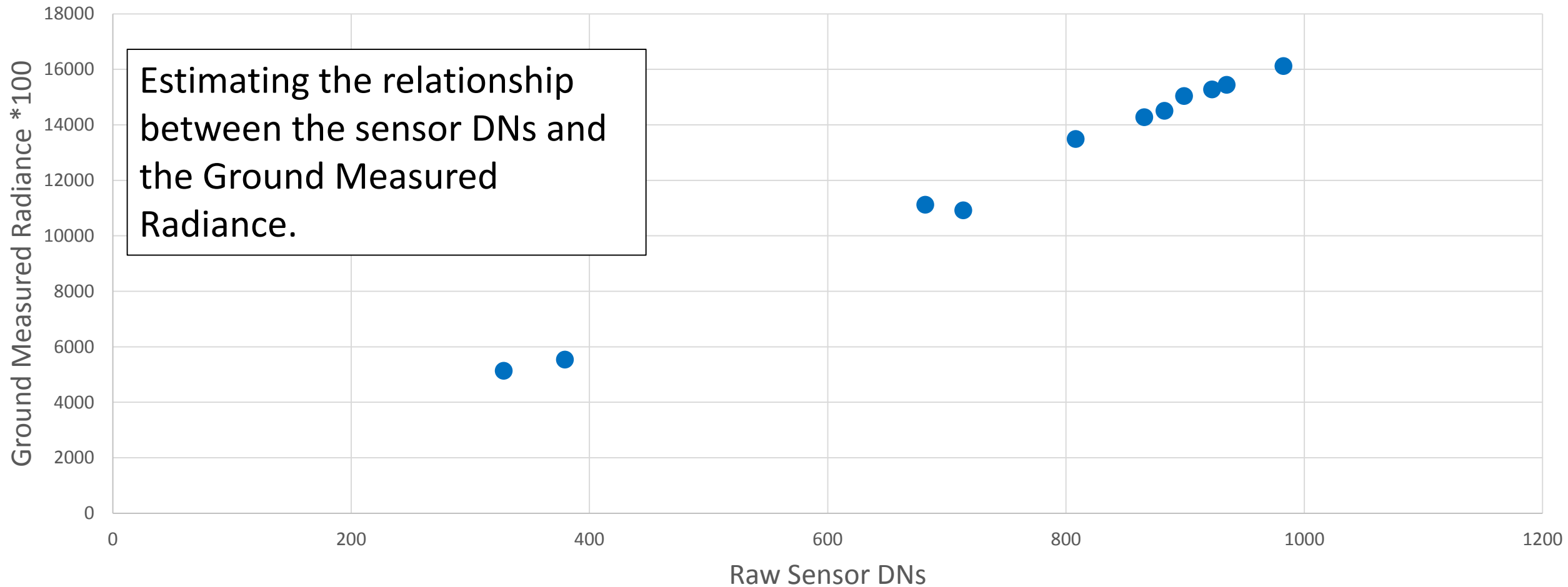
ABSOLUTE UPDATE

RAW SENSOR DNS



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RapidEye 3 Blue Band

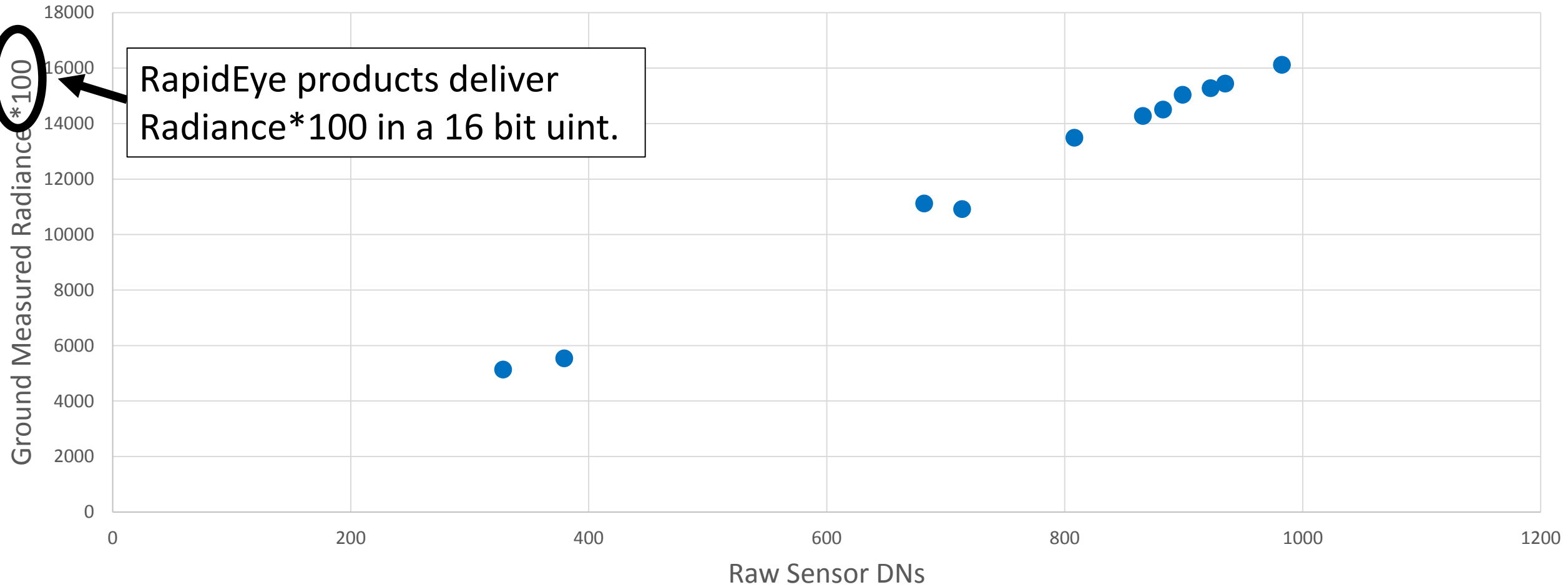


RAW SENSOR DNS



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RapidEye 3 Blue Band

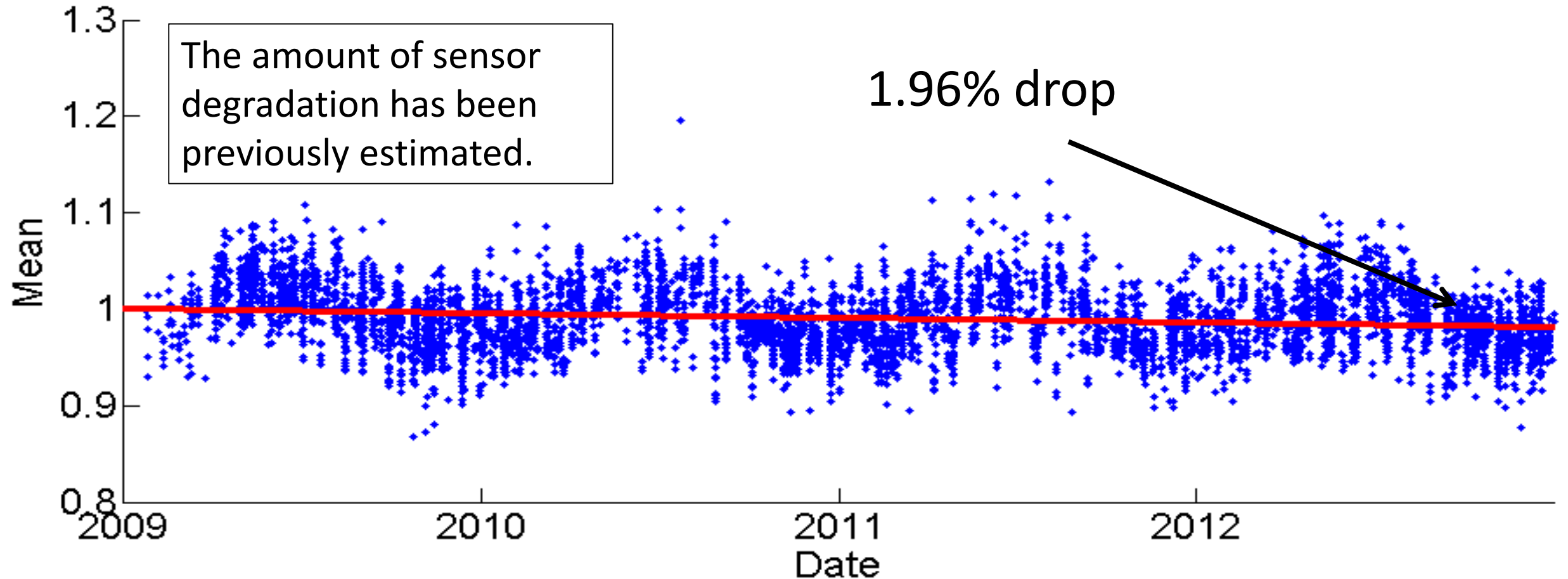


TEMPORAL CORRECTION



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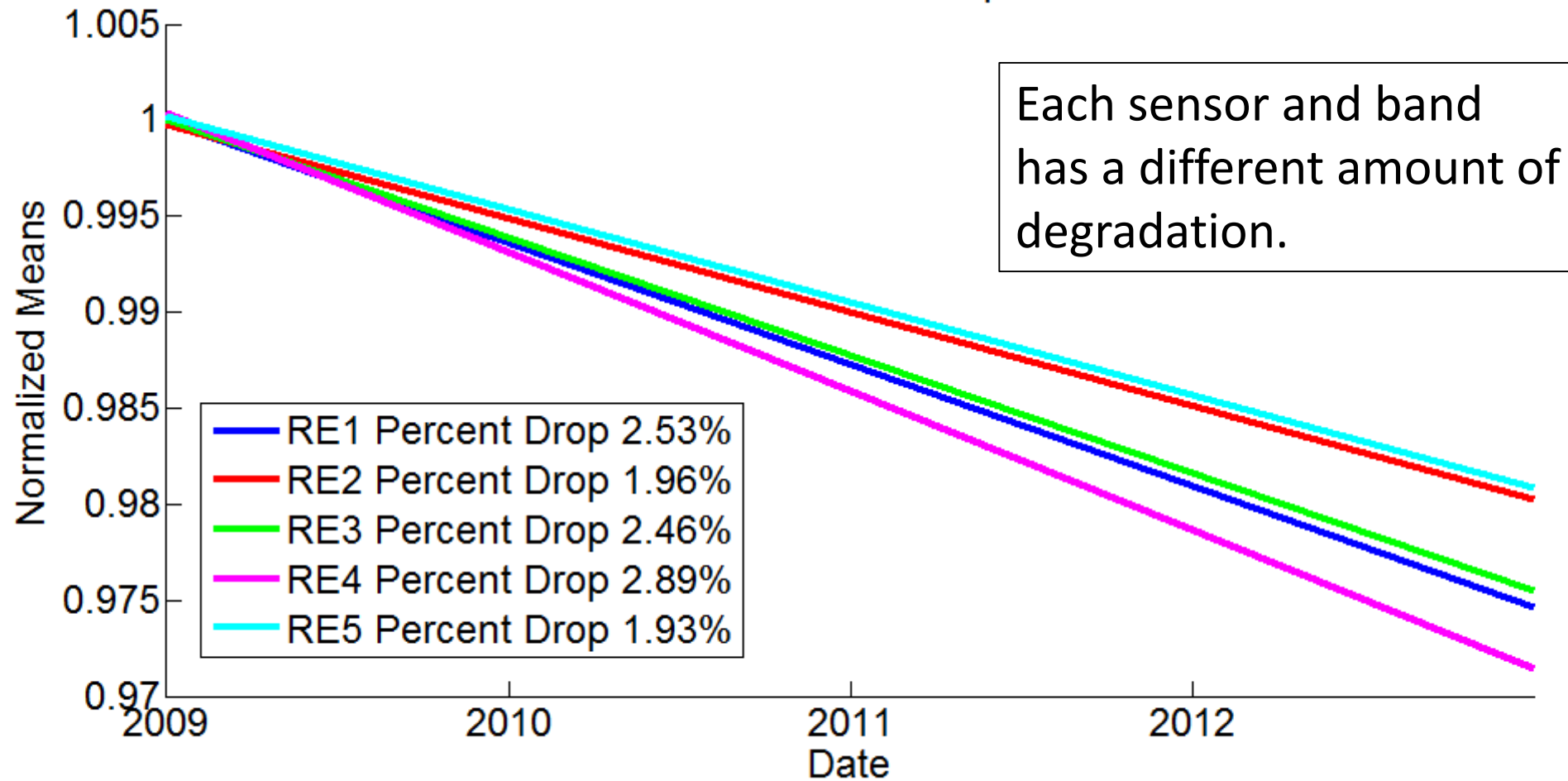
Total Site Means



TEMPORAL CORRECTION (CONT.)



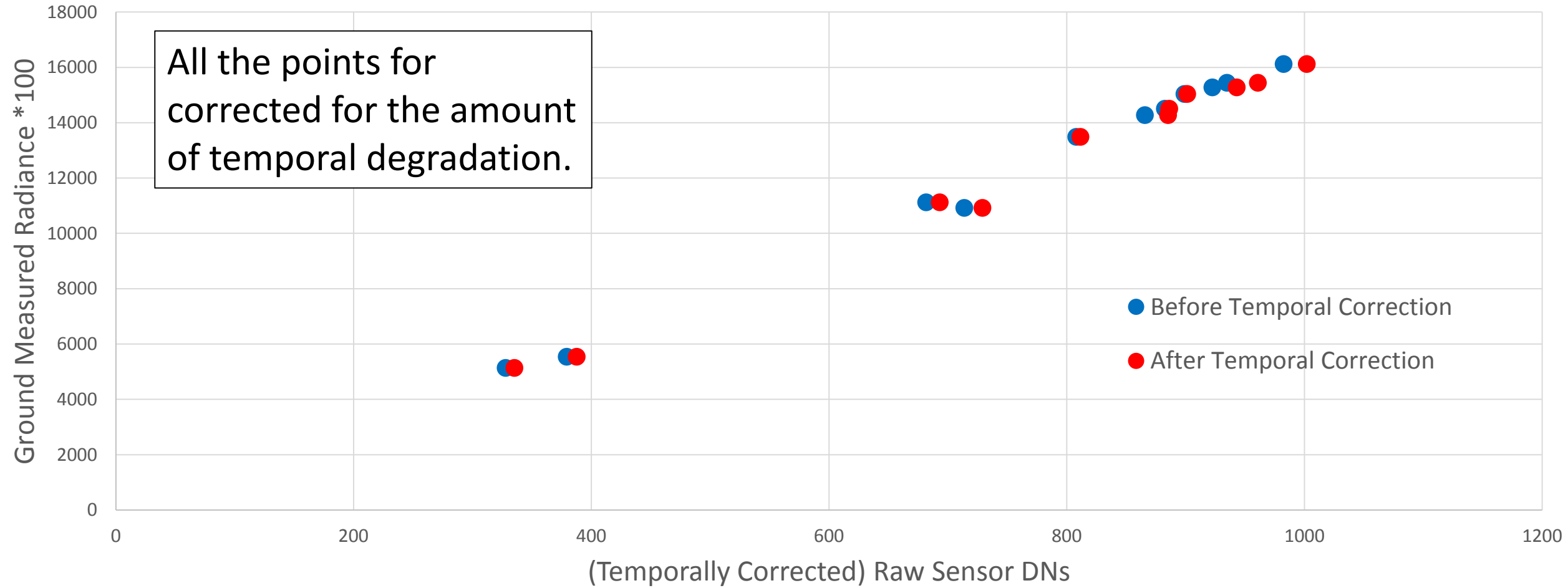
Band 1 Linear Fit Comparison



TEMPORAL CORRECTION (CONT.)

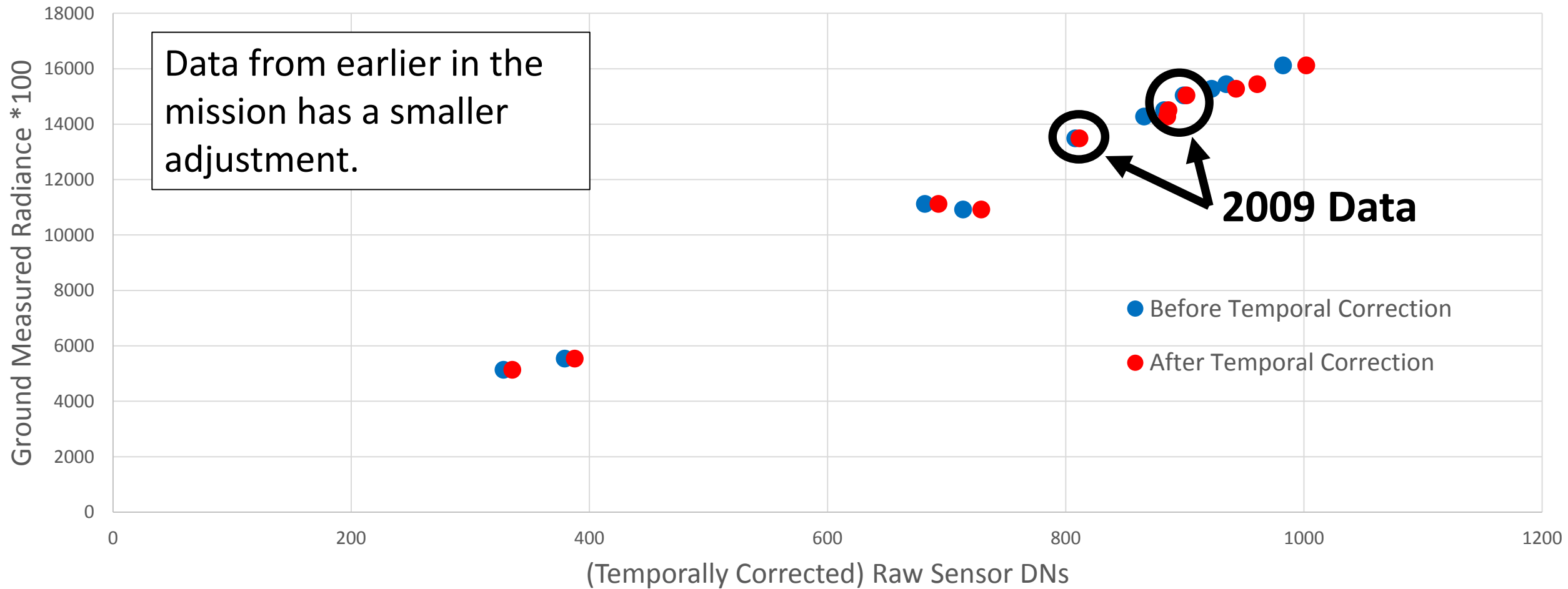


RapidEye 3 Blue Band



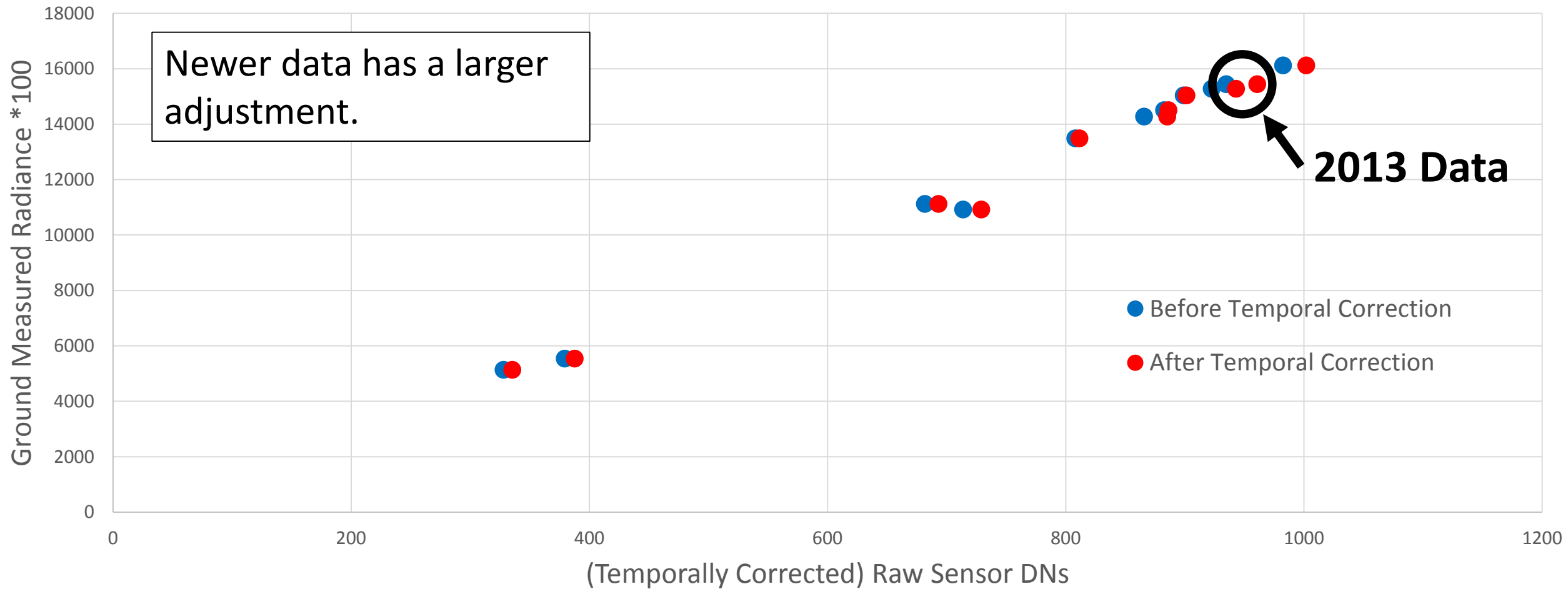
TEMPORAL CORRECTION (CONT.)

RapidEye 3 Blue Band



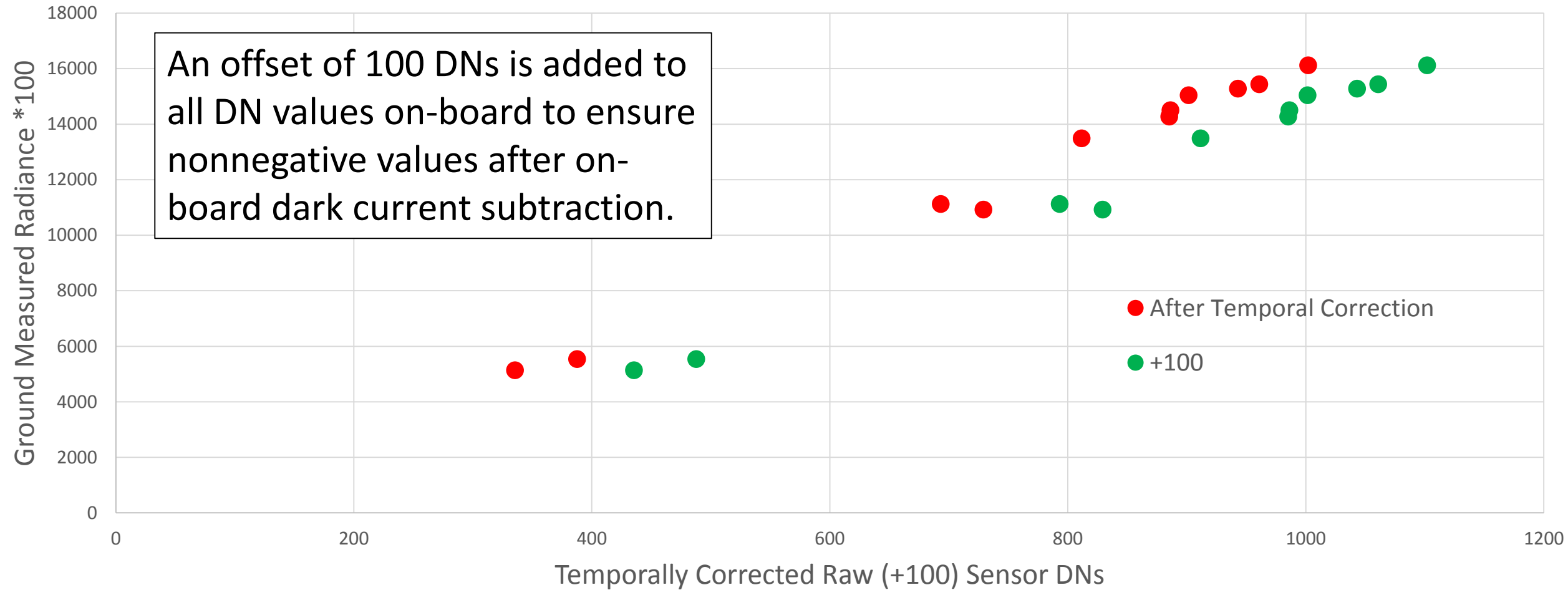
TEMPORAL CORRECTION (CONT.)

RapidEye 3 Blue Band



“RAW” RECEIVED SENSOR DNs

RapidEye 3 Blue Band

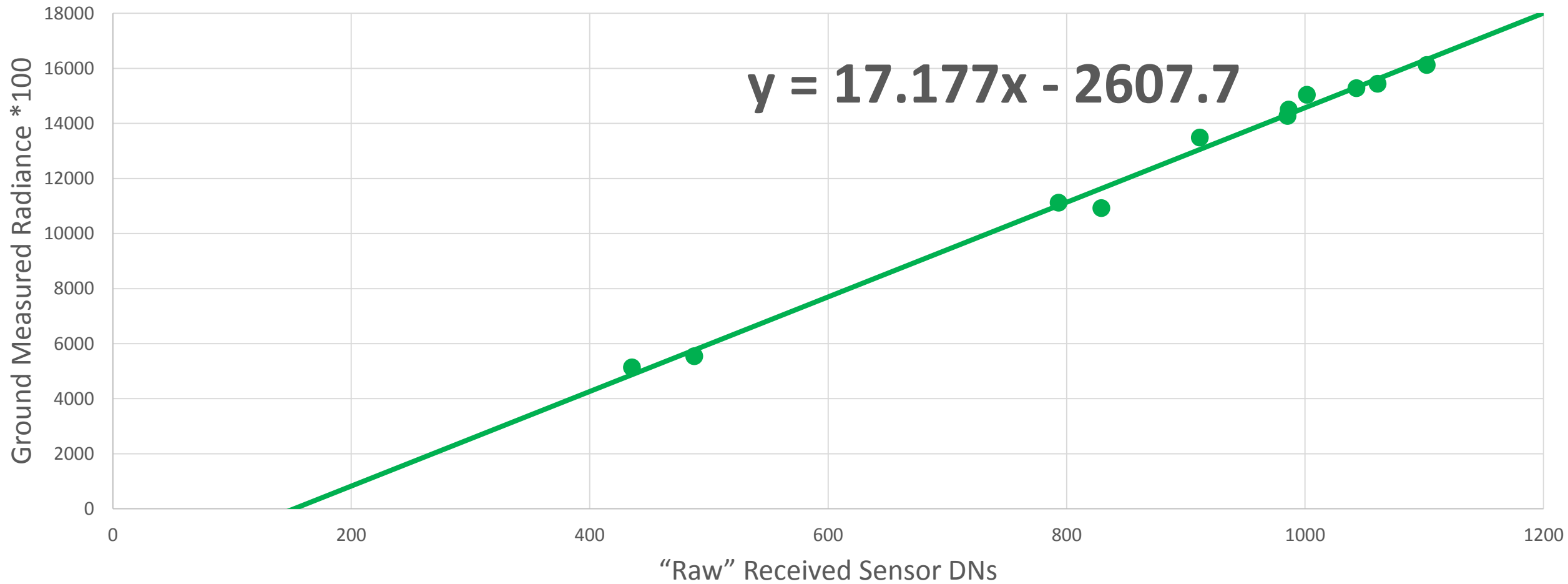


LINEAR FIT



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RapidEye 3 Blue Band

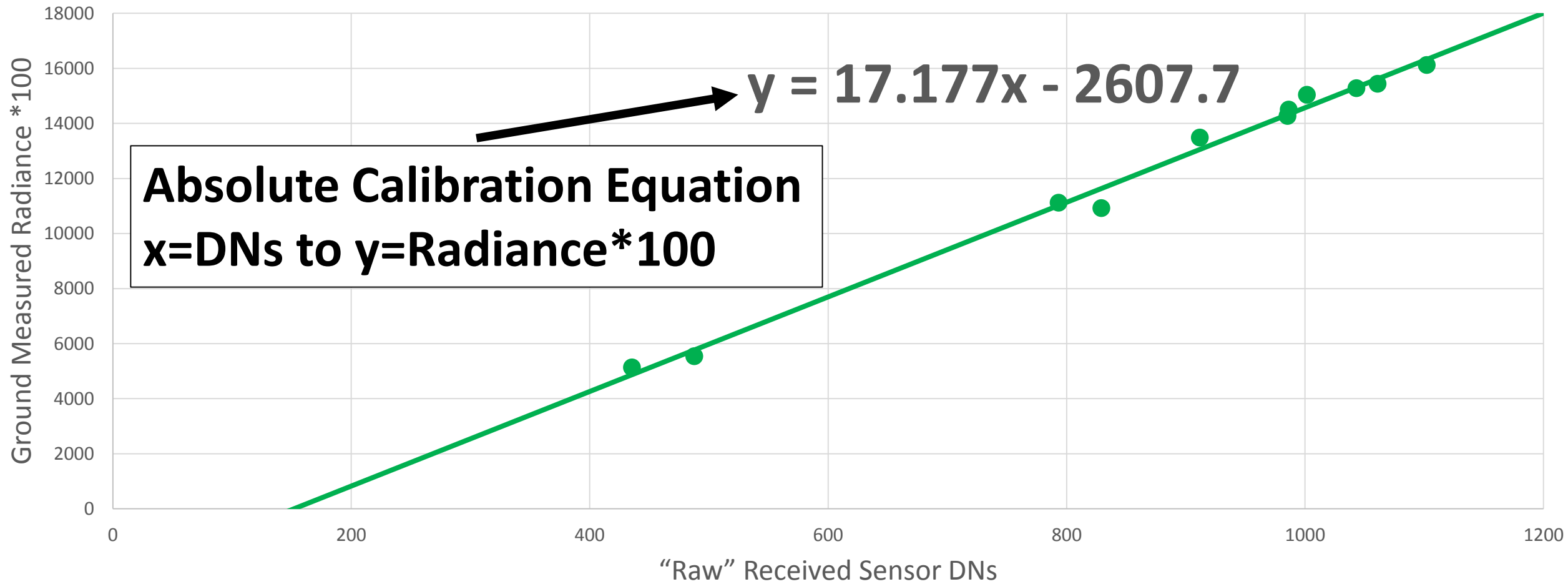


LINEAR FIT



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RapidEye 3 Blue Band





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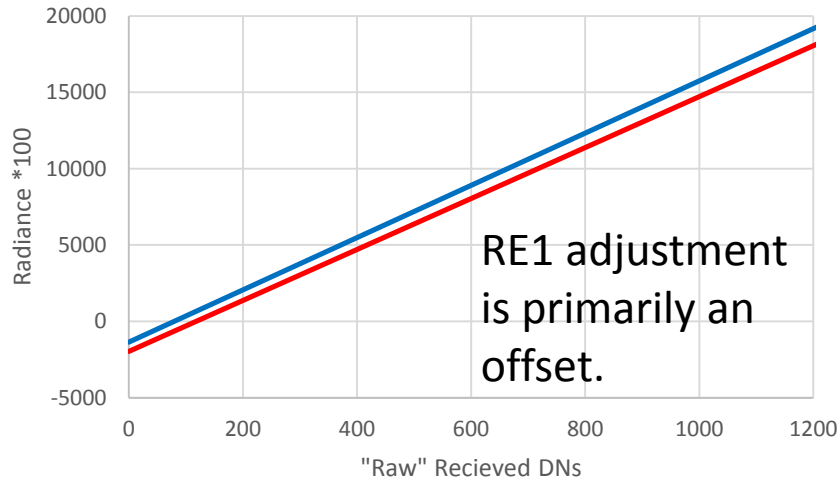
RESULTS OF THE UPDATE

BLUE BAND

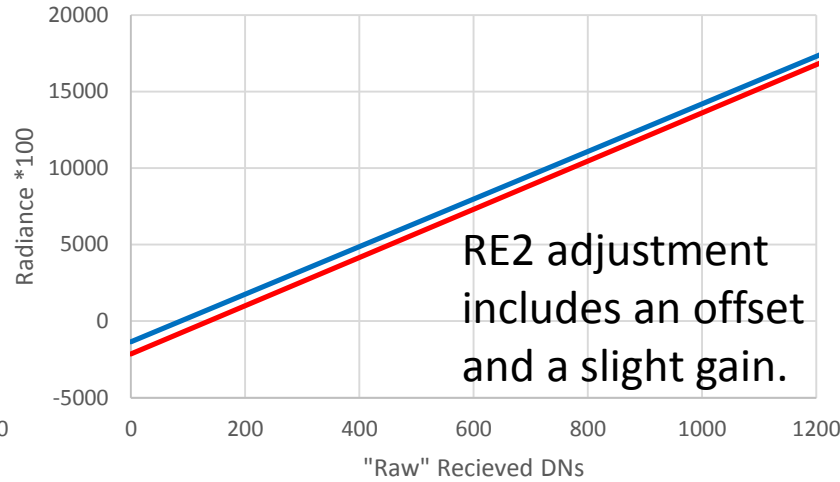
OLD AND NEW GAIN AND OFFSET COMPARISON



RapidEye 1 Band 1

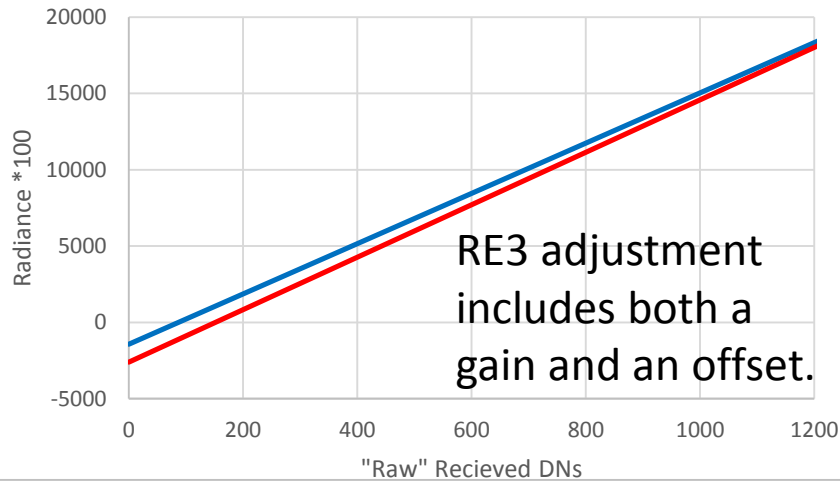


RapidEye 2 Band 1

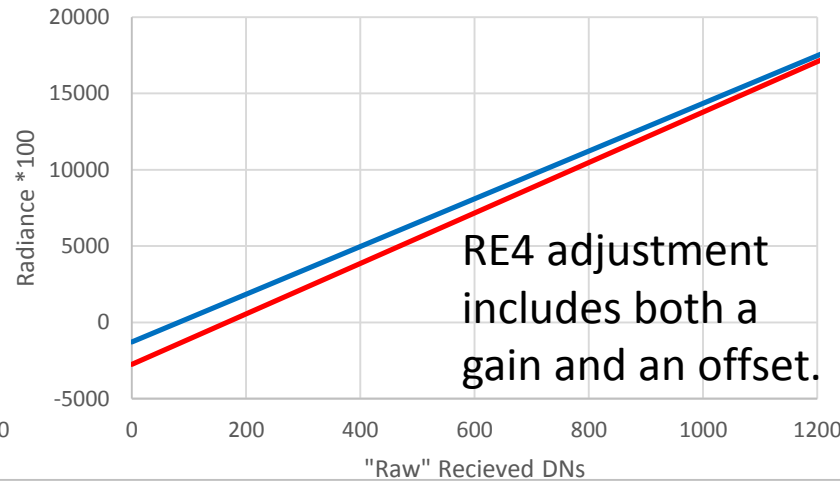


- OLD
- NEW

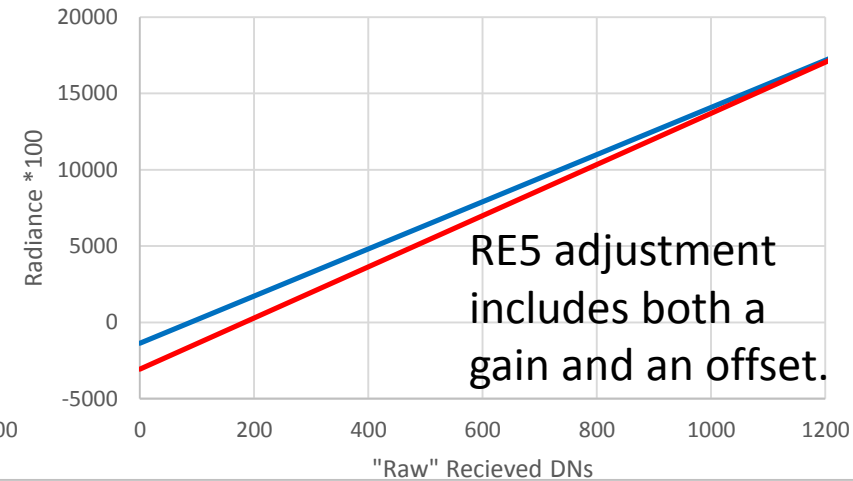
RapidEye 3 Band 1



RapidEye 4 Band 1



RapidEye 5 Band 1

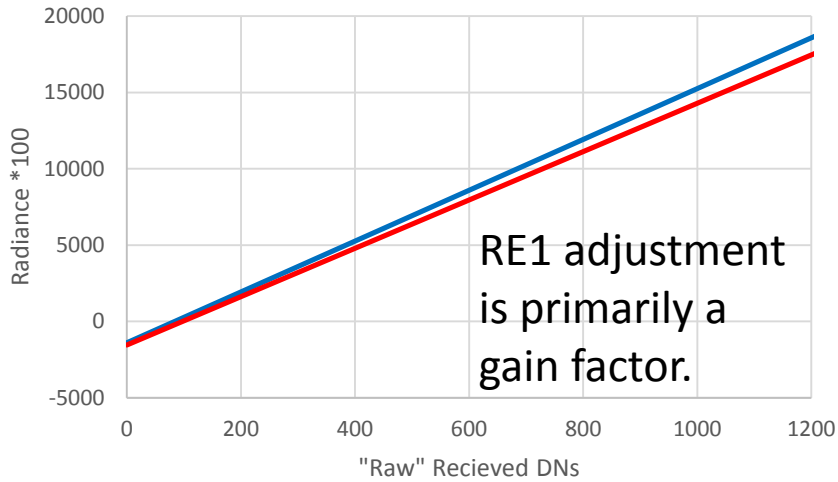


GREEN BAND

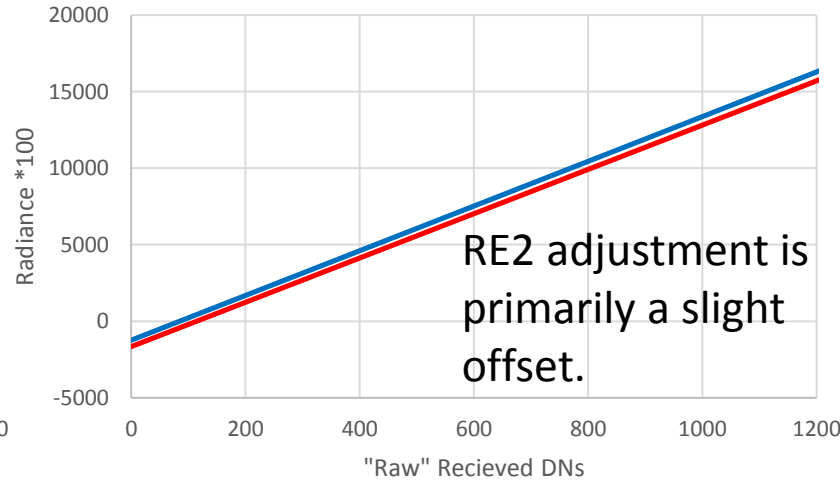
OLD AND NEW GAIN AND OFFSET COMPARISON



RapidEye 1 Band 2

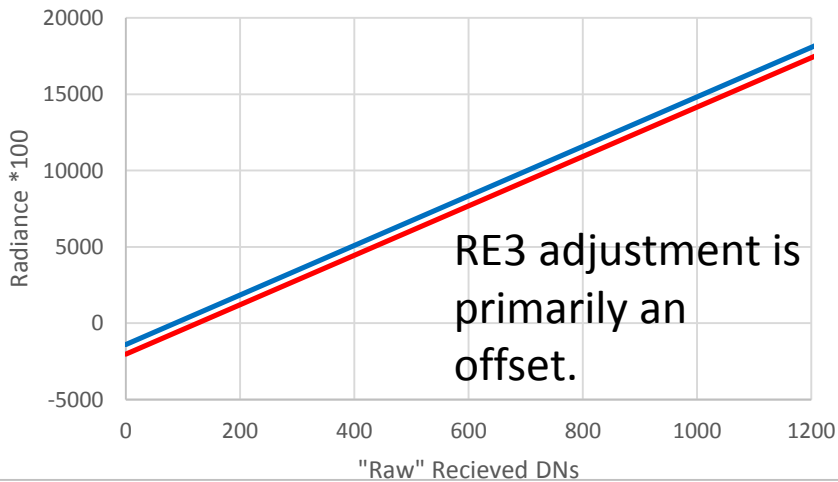


RapidEye 2 Band 2

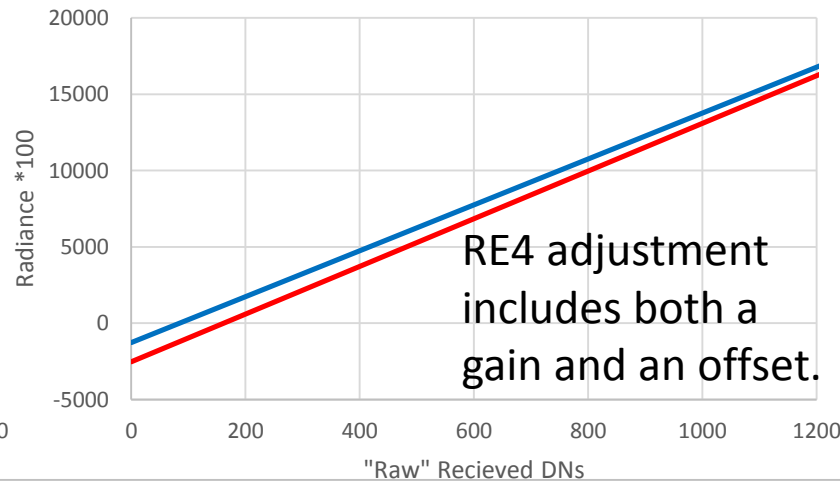


- OLD
- NEW

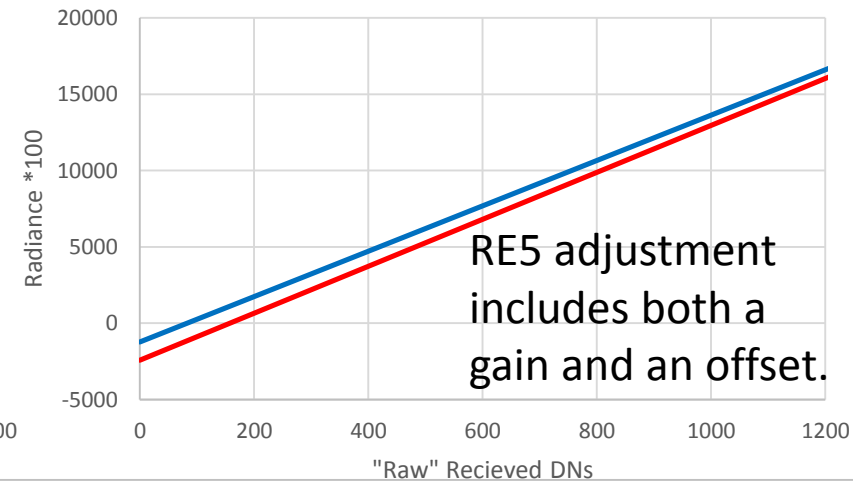
RapidEye 3 Band 2



RapidEye 4 Band 2



RapidEye 5 Band 2

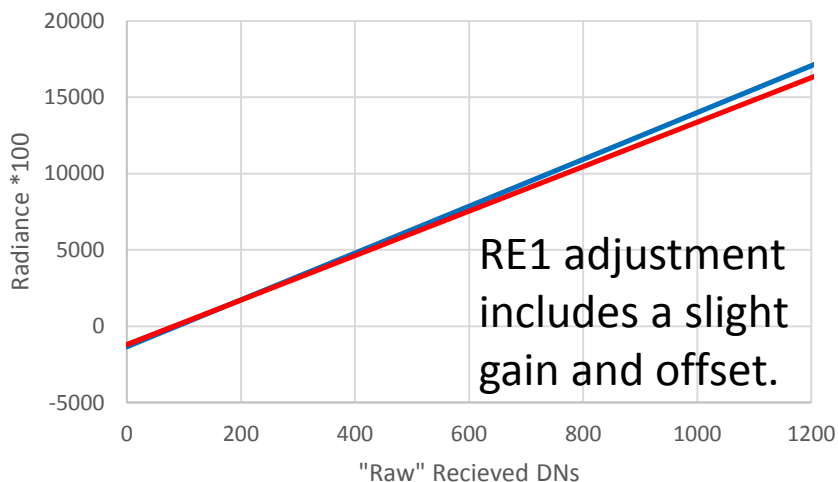


RED BAND

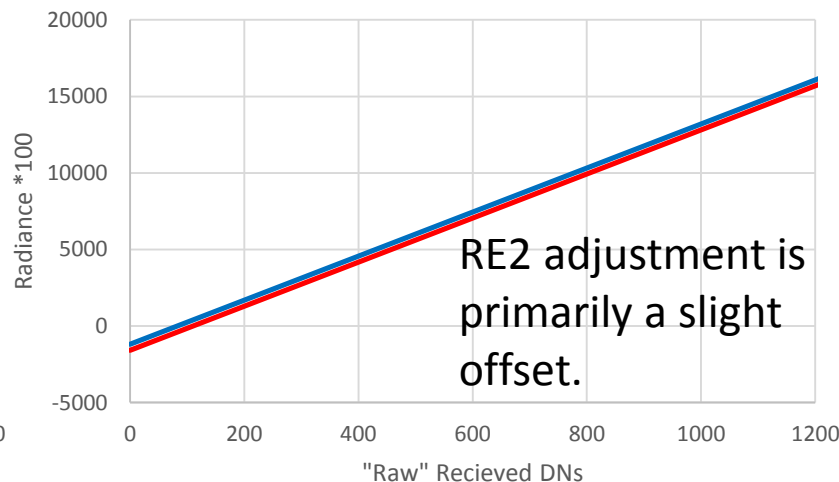
OLD AND NEW GAIN AND OFFSET COMPARISON



RapidEye 1 Band 3

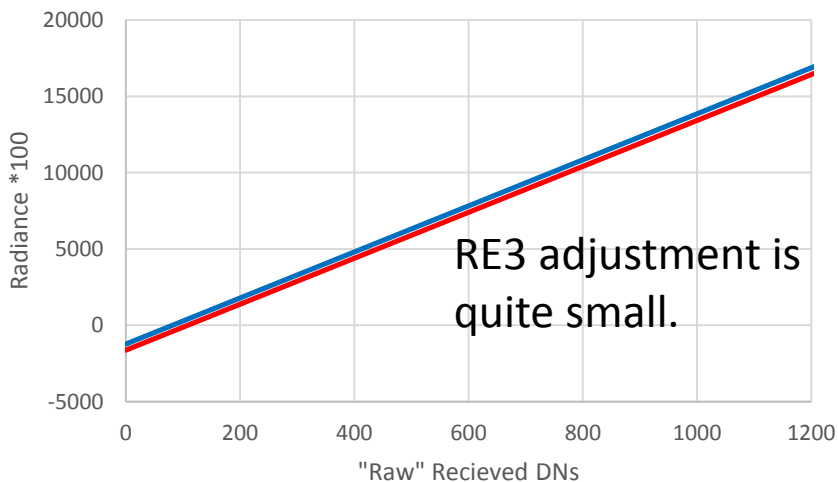


RapidEye 2 Band 3

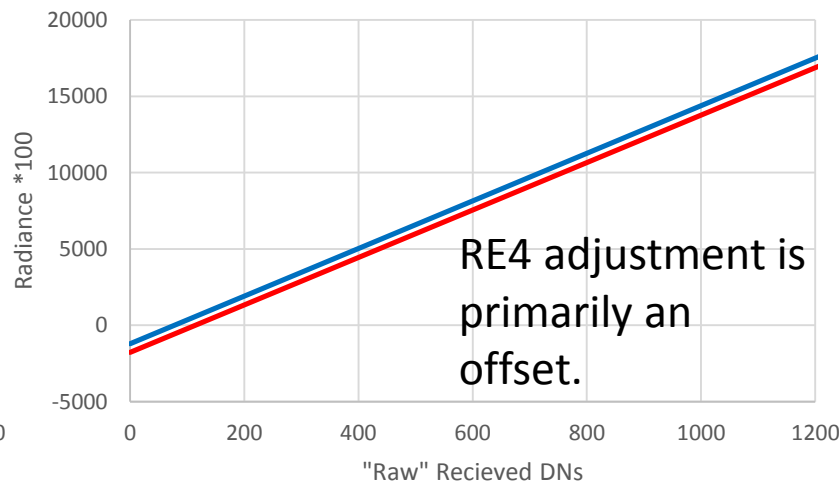


- OLD
- NEW

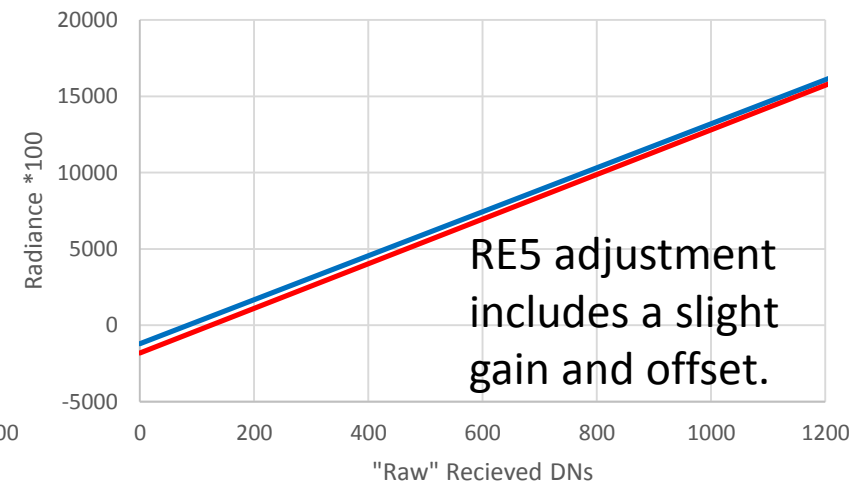
RapidEye 3 Band 3



RapidEye 4 Band 3



RapidEye 5 Band 3

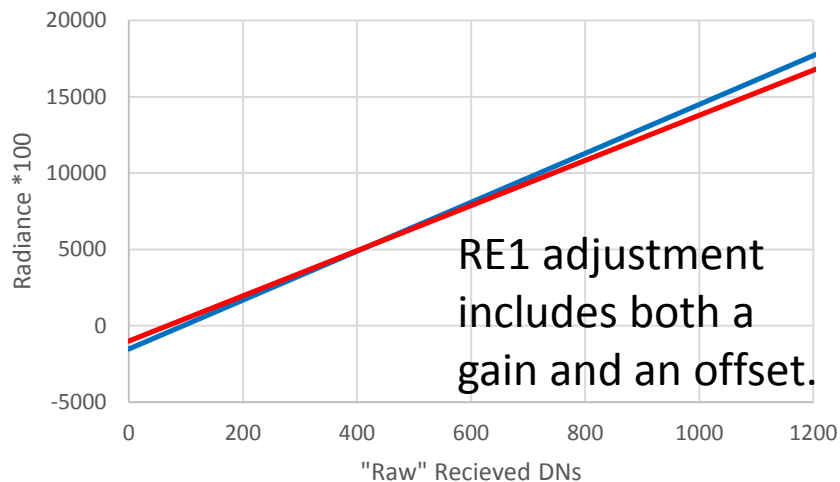


RED-EDGE BAND OLD AND NEW GAIN AND OFFSET COMPARISON

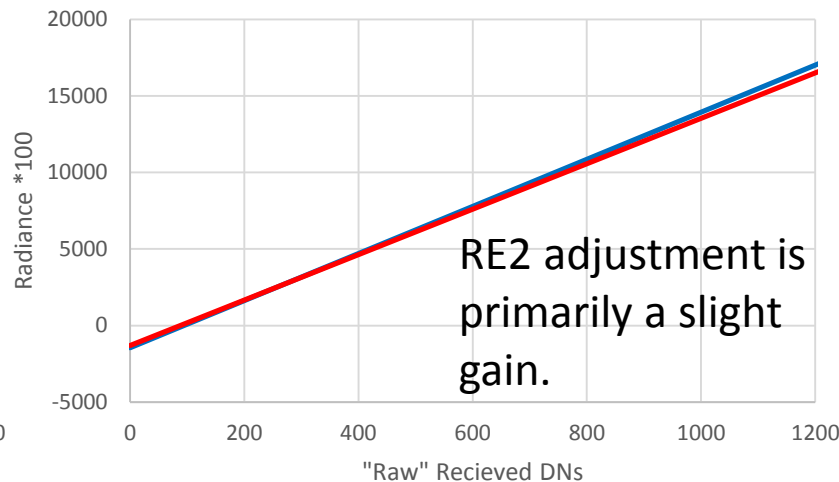


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RapidEye 1 Band 4

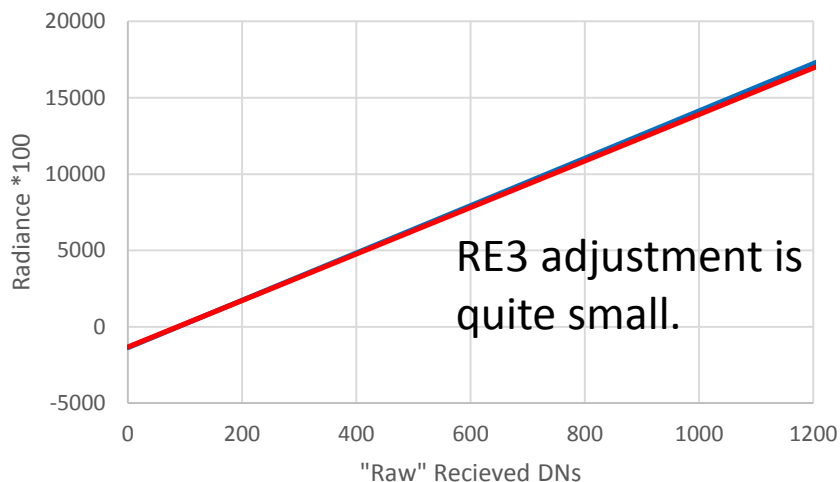


RapidEye 2 Band 4

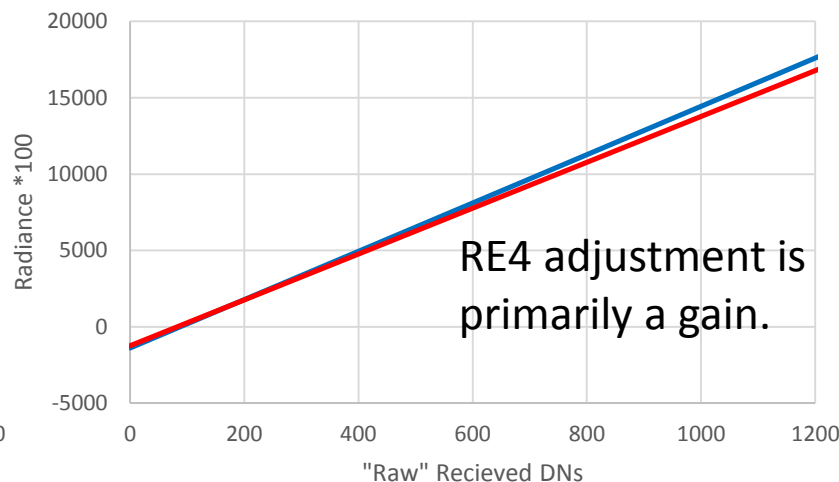


- OLD
- NEW

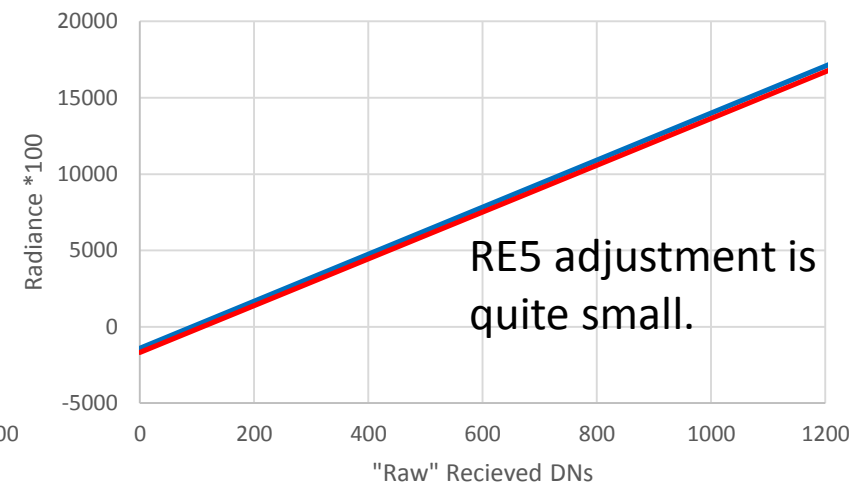
RapidEye 3 Band 4



RapidEye 4 Band 4



RapidEye 5 Band 4

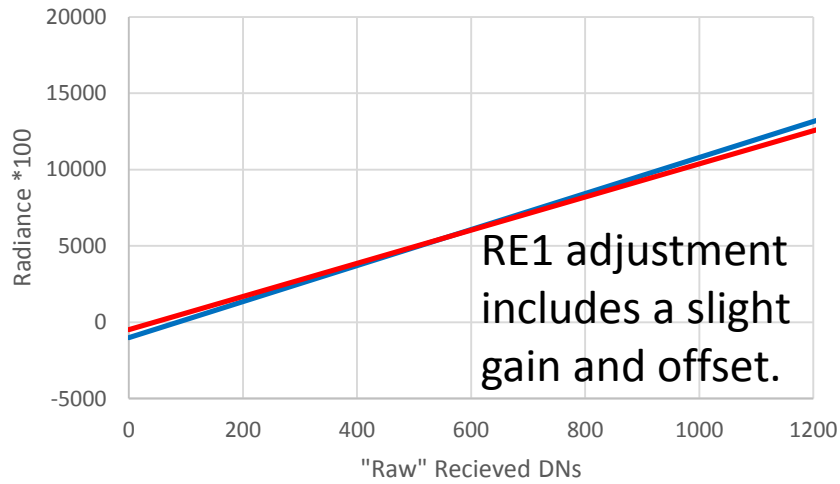


NIR BAND

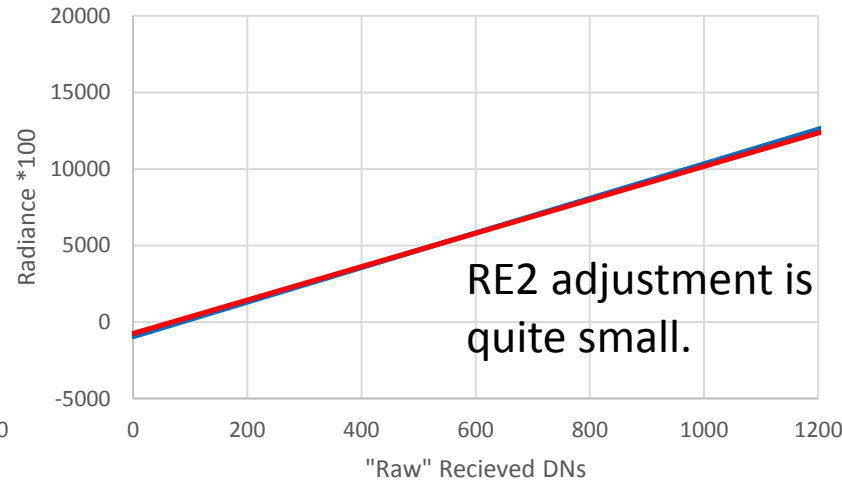
OLD AND NEW GAIN AND OFFSET COMPARISON



RapidEye 1 Band 5

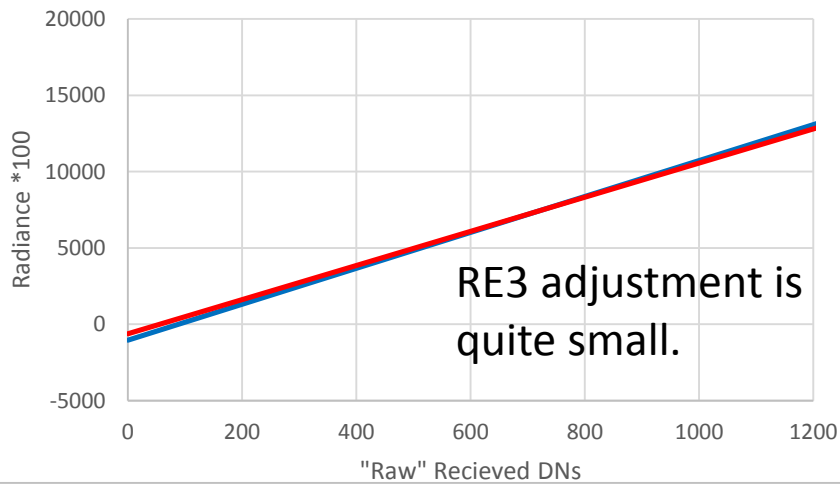


RapidEye 2 Band 5

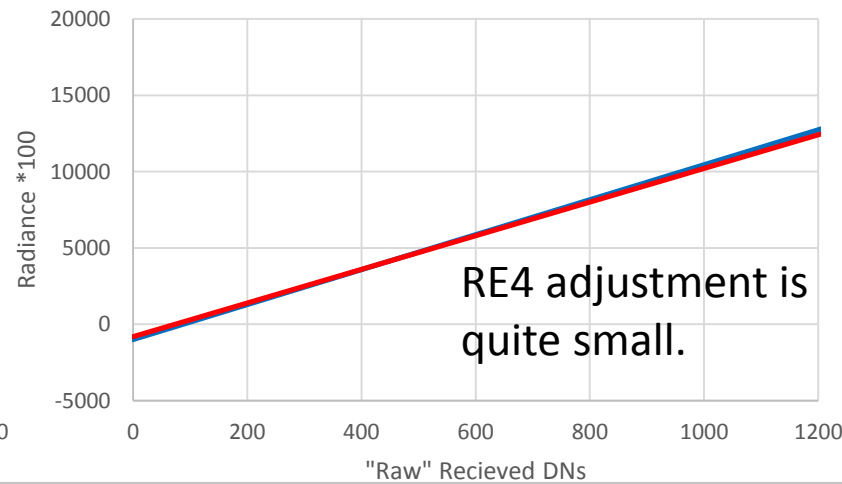


- OLD
- NEW

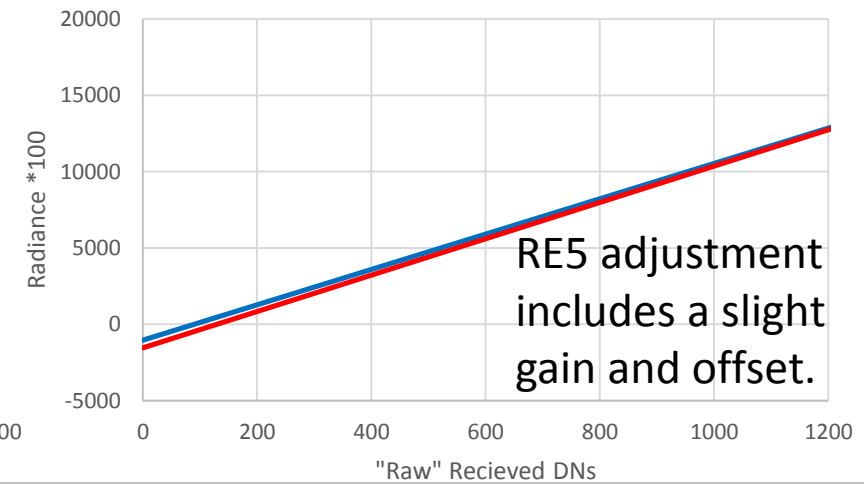
RapidEye 3 Band 5



RapidEye 4 Band 5



RapidEye 5 Band 5





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VALIDATION

2014 VICARIOUS MEASUREMENTS



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- We have performed a number of vicarious campaigns in 2014.
- UofA: 4 satellites from May 9-13, 2014 (RE 1-4).
- SDSU: 4 satellites from June 10 – July 6 (RE 2-5).

RAILROAD VALLEY 2014 RESULTS



Percent Differences Between Field Measurements and Imagery

	RE1	RE2	RE3	RE4	RE5
Blue	1.14	2.49	-0.54	1.25	X
Green	0.36	2.19	-1.12	-1.08	X
Red	0.86	0.01	0.08	-1.02	X
Red-Edge	-0.69	-1.46	-0.41	-1.15	X
NIR	-0.21	-1.62	0.24	-0.48	X
Total Collects	1	1	1	1	0

- Previously the results over railroad value agreed well, but while only having one collect each, the results look more promising than before the update.
- All sensors are less than 2.5%.
- There was no successful collect with RE5.

BROOKINGS 2014 RESULTS



Percent Differences Between Field Measurements and Imagery

	RE1	RE2	RE3	RE4	RE5
Blue	X	0.87	5.64	-2.97	-2.15
Green	X	1.61	4.04	2.37	1.13
Red	X	4.88	3.64	0.40	-1.10
Red-Edge	X	-3.72	-5.00	-6.43	-4.92
NIR	X	-0.34	-4.07	-3.78	-2.15
Total Collects	0	1	1	1	1

- With only one collect each, the update appears to have vastly improved the results over this darker site.
- The 6.43% difference in RE4 Red-Edge will have to be watched.
- There was no successful collect with RE1.



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CONCLUSIONS

CONCLUSIONS



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- Results from 2014 vicarious collects confirm that the RapidEye Constellation is well calibrated.
- All satellites and bands have been updated as of Jan. 24, 2014.
- BlackBridge will provide assistance to any customers who have previously purchased data and would like to update it to the new absolute calibration.



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