Investigating the Effects of Variable Water Type for VIIRS Calibration

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On-orbit calibration technique, NASA OBPG:

- adjusts the satellite radiance at the TOA
  - measure radiance at the ocean surface (ground truth) propagate to TOA
  - calculate the adjustment (gain) for visible bands (400-700 nm, M1-M5).
- There are very clear rules outlined in this paper.

Sensor-independent approach to the vicarious calibration of satellite ocean color radiometry

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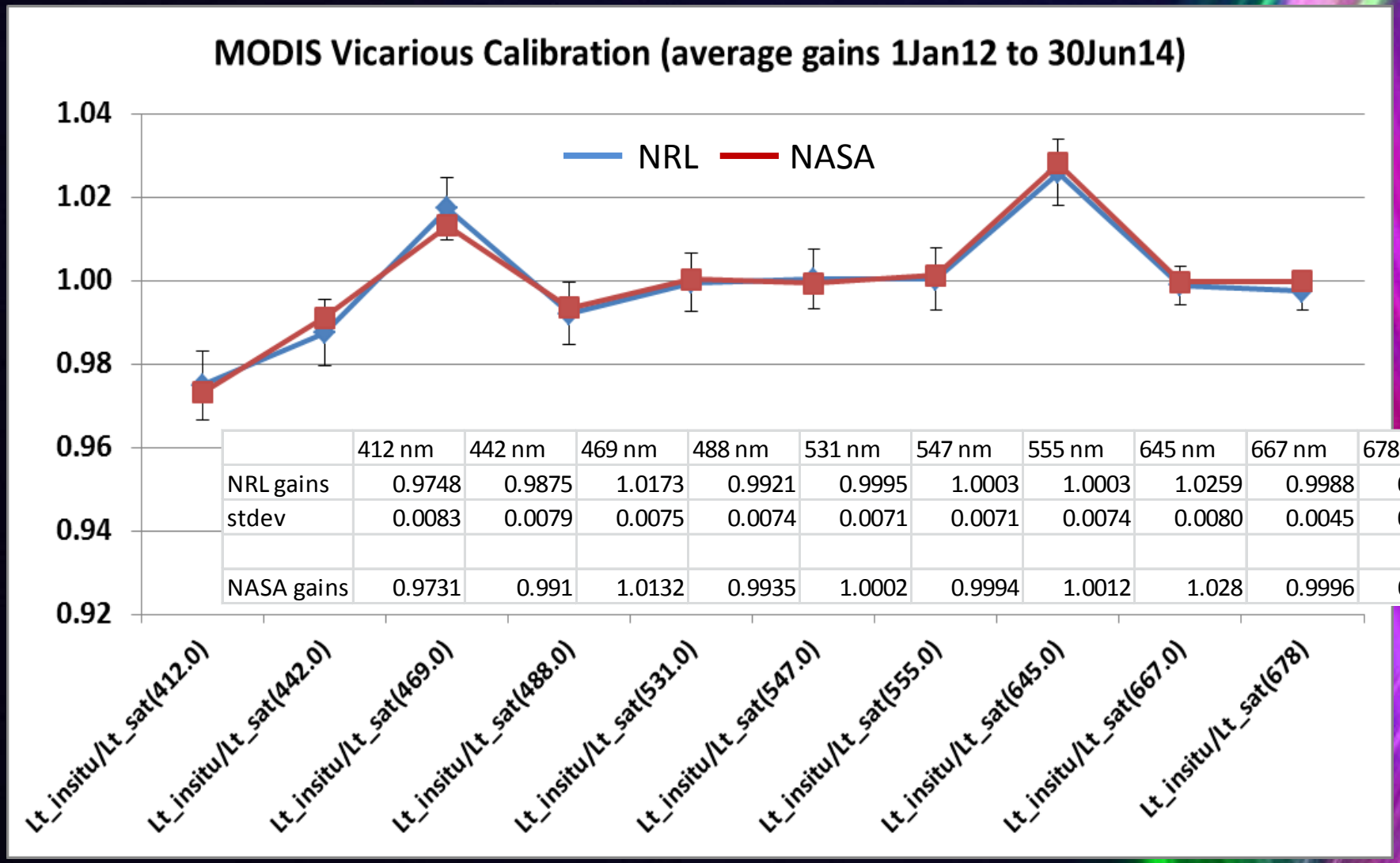
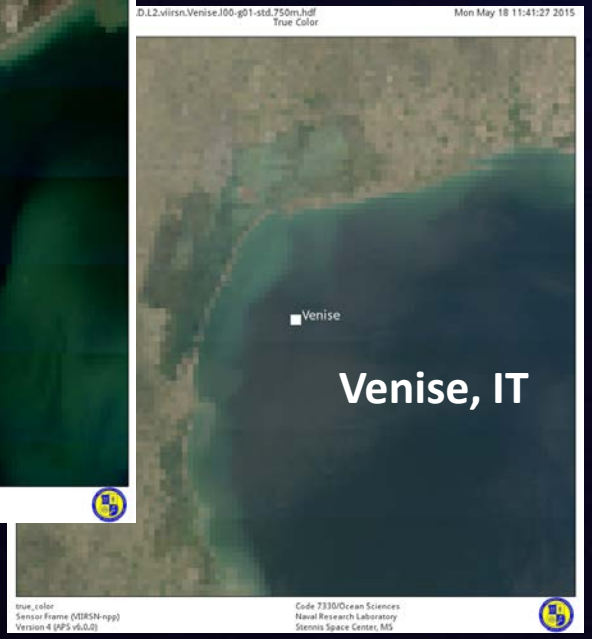
The retrieval of ocean color radiometry from space-based sensors requires on-orbit vicarious calibration to achieve the level of accuracy desired for quantitative oceanographic applications. The approach developed by the NASA Ocean Biology Processing Group (OBPG) adjusts the integrated instrument and atmospheric correction system to retrieve normalized water-leaving radiances that are in agreement with ground truth measurements. The method is independent of the satellite sensor or the source of the ground truth data, but it is specific to the atmospheric correction algorithm. The OBPG vicarious calibration approach is described in detail, and results are presented for the operational calibration of SeaWiFS using

To validate OBPGs technique and demonstrate that NRL understands "the rules", we show NRL and NASA spectral gains are equivalent for overlapping MODIS time frame.



	412 nm	442 nm	469 nm	488 nm	531 nm	547 nm	555 nm	645 nm	667 nm	678 nm
NRL gains	0.9748	0.9875	1.0173	0.9921	0.9995	1.0003	1.0003	1.0259	0.9988	0.9975
stdev	0.0083	0.0079	0.0075	0.0074	0.0071	0.0071	0.0074	0.0080	0.0045	0.0046
NASA gains	0.9731	0.991	1.0132	0.9935	1.0002	0.9994	1.0012	1.028	0.9996	0.9998

Following established methodology, requires coincident satellite and *in situ* matchups from environmentally stable waters under clear atmospheric conditions. Often requiring 1+ year before a stable calibration is achieved.



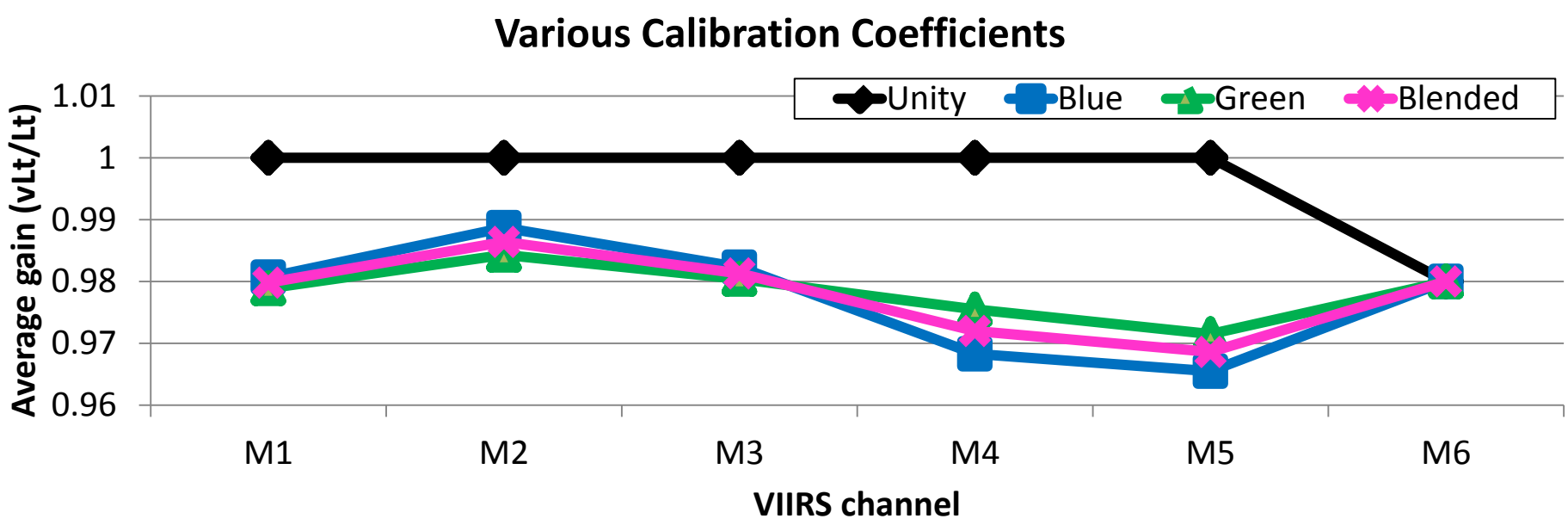
But **<u>what if</u>** we also used high quality matchups from coastal AERONET-OC sites? - complex ocean and atmospheric conditions

Using data from MOBY and A-OC: WCIS and Venise we generate various calibration coefficients.

SCREENING CRITERIA:

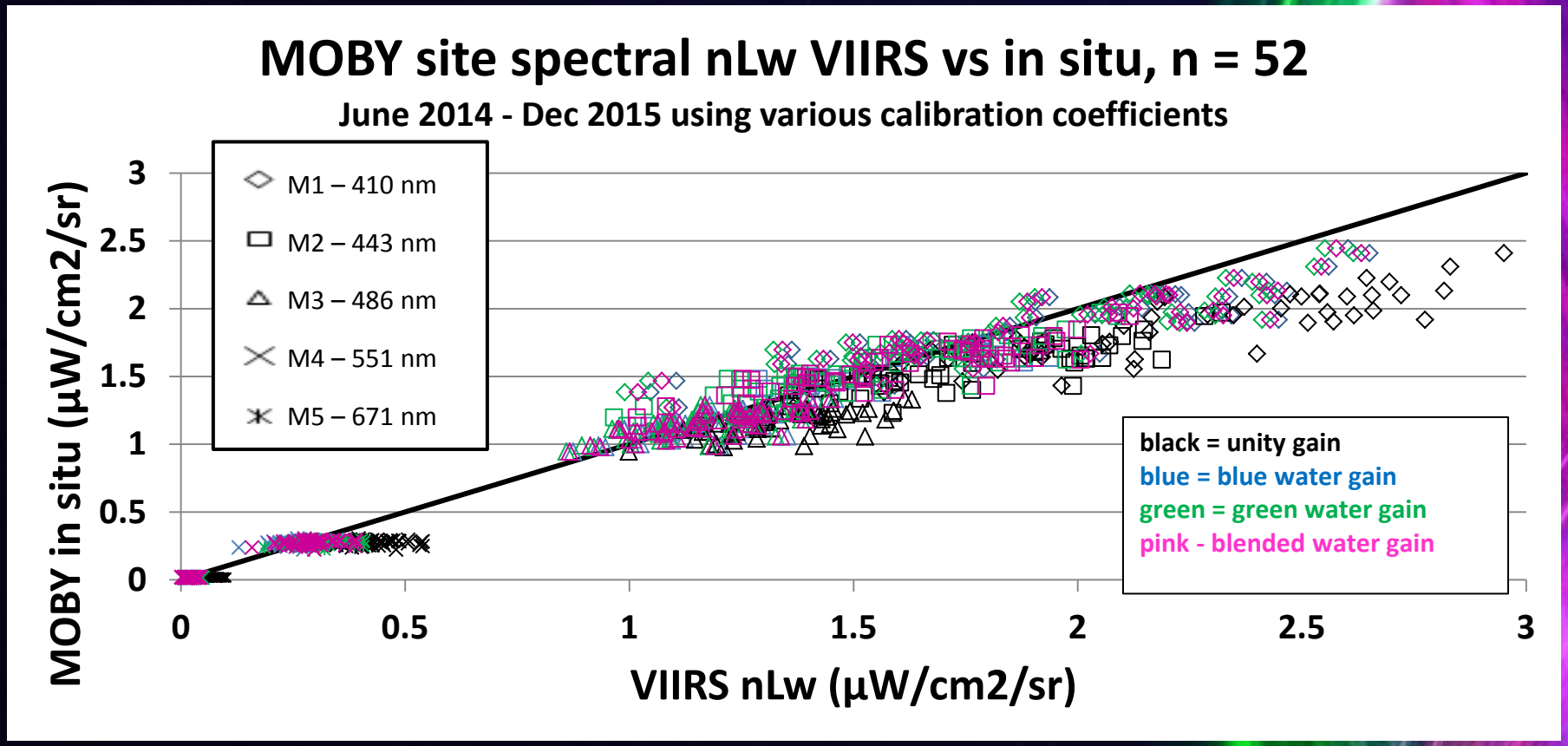
- *In situ* data ±3 hours of overpass
- no flags allowed on satellite imagery
- wind speed < 8 m/s
- 0.001 < nLw values < 3.0
- solar zenith angle < 70 degrees
- sensor zenith angle < 56 degrees
- *Visual screening to remove outliers*

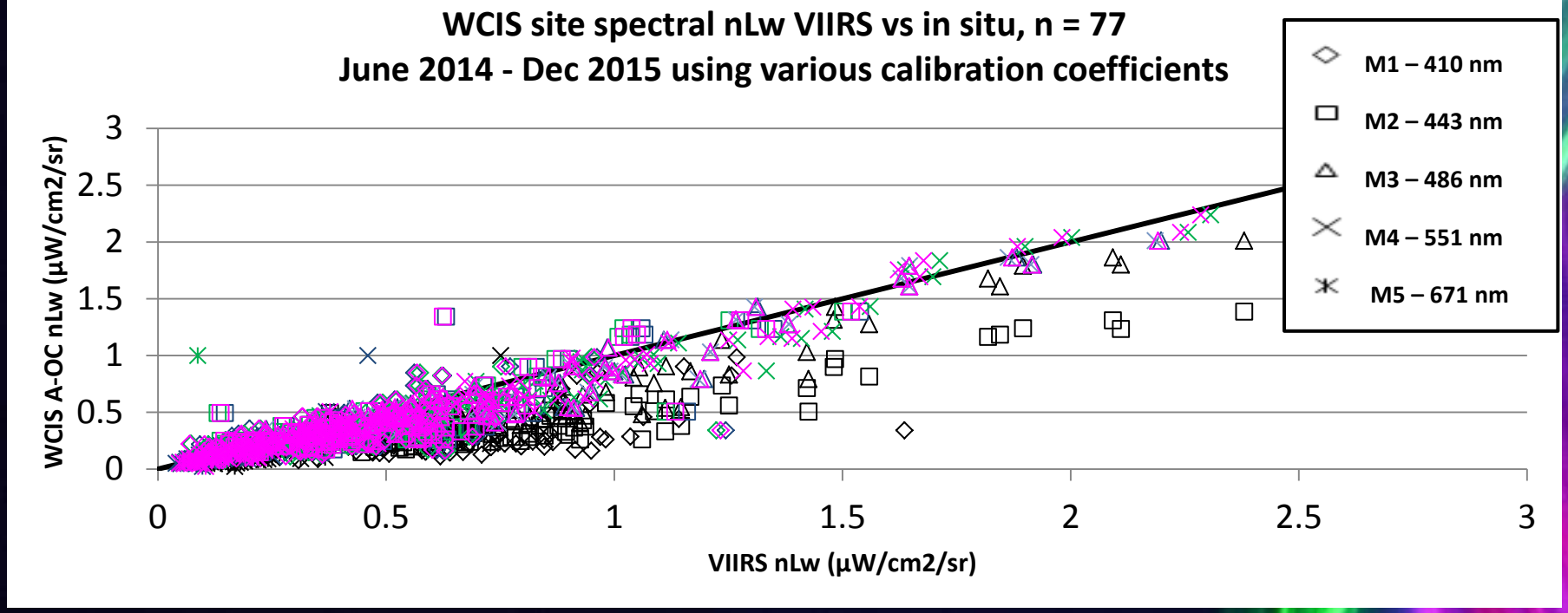
Calibration coefficients	M1	M2	M3	M4	M5	M6
Unity	1	1	1	1	1	0.98
blue, n = 23	0.9807	0.9887	0.9823	0.9683	0.9655	0.98
blue stdev	0.0105	0.0090	0.0079	0.0066	0.0062	
green, n = 24	0.9789	0.9843	0.9804	0.9755	0.9715	0.98
green stdev	0.0130	0.0112	0.0116	0.0132	0.0134	
blended, n = 47	0.9798	0.9864	0.9813	0.9720	0.9686	0.98
blended stdev	0.0118	0.0103	0.0099	0.0110	0.0108	

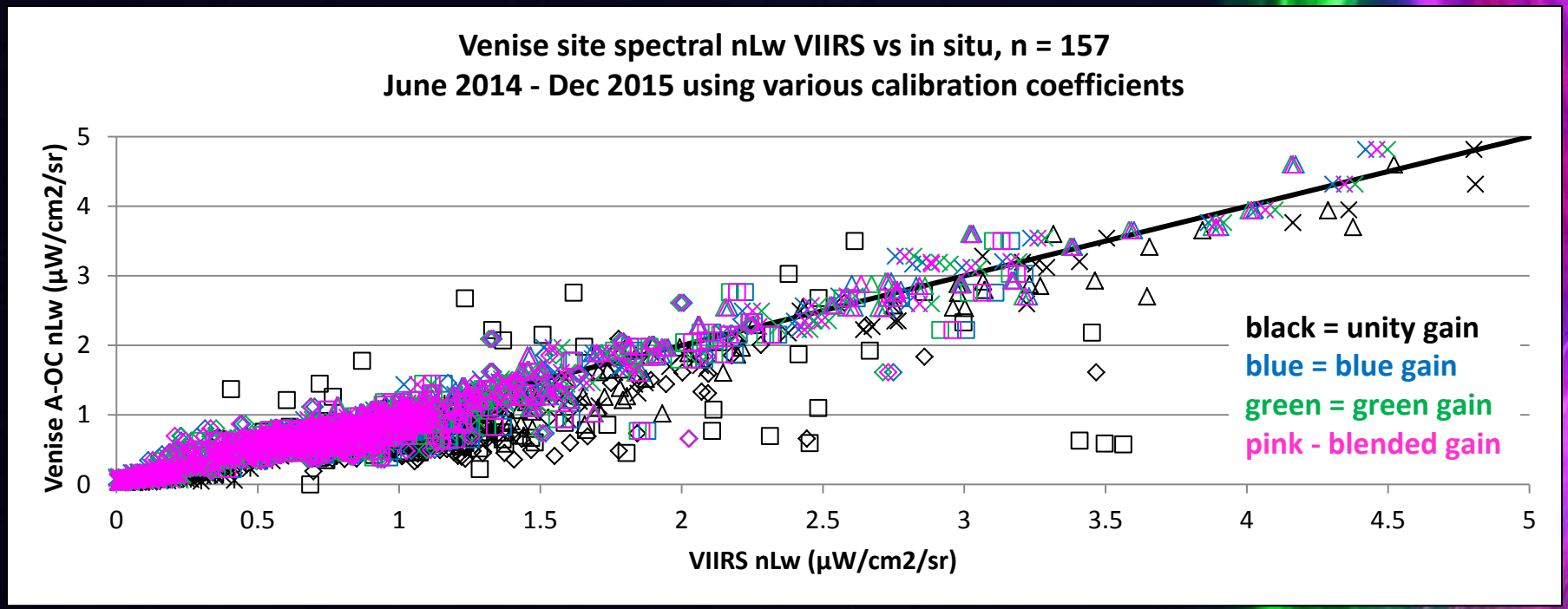


Process VIIRS imagery (NRT SDR) collected between June 2014 and December 2015 at MOBY and the green water AERONET sites: WCIS (Gulf of Mexico) and Venise (Italy) with the different calibration coefficients.

Aggregate satellite and *in situ* matchups: +/- 3 hours, a solar zenith angle <70, sensor zenith angle <56 degrees and remove matchups with glint and/or clouds. Validation is performed at the sea surface (nLw).



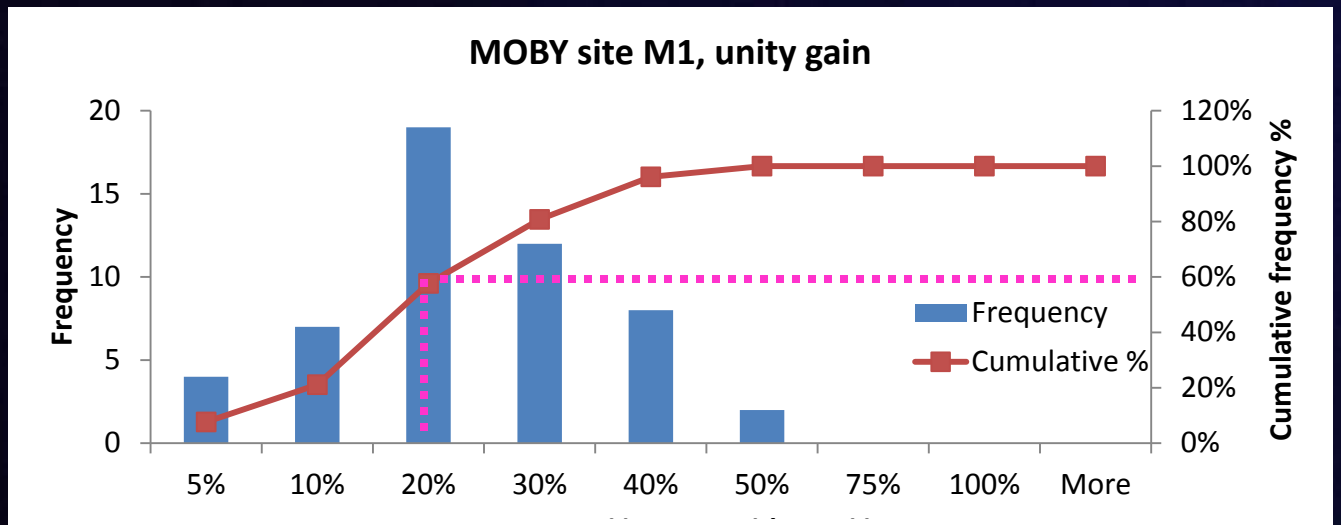

WCIS site spectral nLw VIIRS vs in situ, n = 77
June 2014 - Dec 2015 using various calibration coefficients
M1 – 410 nm
M2 – 443 nm
M3 – 486 nm
M4 – 551 nm
M5 – 671 nm
WCIS A-OC nLw (µW/cm2/sr)
VIIRS nLw (µW/cm2/sr)
0
0.5
1
1.5
2
2.5
3


Venise site spectral nLw VIIRS vs in situ, n = 157
June 2014 - Dec 2015 using various calibration coefficients
black = unity gain
blue = blue gain
green = green gain
pink - blended gain
Venise A-OC nLw (µW/cm2/sr)
VIIRS nLw (µW/cm2/sr)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

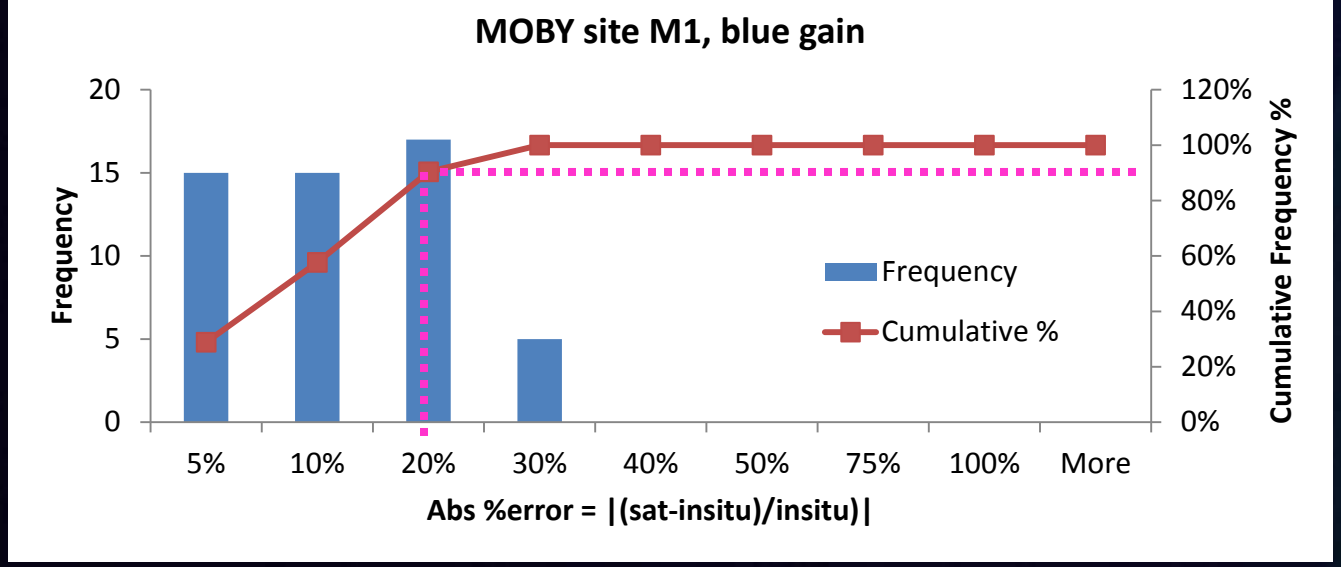
MOBY, n= 52		VIIRS range	In situ range	Slope, r^2	Median ratio	Median Abs%diff	RMSE
UNITY	M1	(1.366, 3.015)	(1.271, 2.445)	(1.2, 0.993)	1.182	18.2	0.193
	M2	(1.156, 2.321)	(1.136, 1.971)	(1.13, 0.994)	1.111	11.1	0.1433
	M3	(0.999, 1.63)	(0.945, 1.334)	(1.166, 0.994)	1.164	16.4	0.103
	M4	(0.319 ,0.539)	(0.223, 0.304)	(1.557, 0.982)	1.566	56.6	0.057
	M5	(0.041, 0.102)	(0.014, 0.02)	(3.969, 0.942)	3.761	276.1	0.0173
BLUE WATER CALIBRATION	M1	(1.047, 2.65)	(1.271, 2.445)	(1.04, 0.99)	1.032	7.1	0.2009
	M2	(1.044, 2.147)	(1.136, 1.971)	(1.046, 0.993)	1.03	7.1	0.1418
	M3	(0.875, 1.459)	(0.945, 1.334)	(1.035, 0.994)	1.024	5.9	0.0917
	M4	(0.129, 0.375)	(0.223, 0.304)	(1.005, 0.974)	1	8.8	0.0449
	M5	(-0.004, 0.038)	(0.014, 0.02)	(0.921, 0.715)	0.807	46.1	0.0102
GREEN WATER CALIBRATION	M1	(0.99, 2.615)	(1.271, 2.445)	(1.021, 0.989)	1.012	8.5	0.2037
	M2	(0.966, 2.087)	(1.136, 1.971)	(1.006, 0.992)	0.995	6.8	0.1439
	M3	(0.86, 1.441)	(0.945, 1.334)	(1.016, 0.994)	1.01	4.9	0.0912
	M4	(0.187, 0.408)	(0.223, 0.304)	(1.131, 0.979)	1.131	13.3	0.0457
	M5	(0.005, 0.048)	(0.014, 0.02)	(1.448, 0.845)	1.39	47.6	0.0109
BLENDED WATER CALIBRATION	M1	(1.019, 2.632)	(1.271, 2.445)	(1.03, 0.989)	1.022	7.9	0.2023
	M2	(1.016, 2.116)	(1.136, 1.971)	(1.025, 0.992)	1.011	7.7	0.1427
	M3	(0.867, 1.449)	(0.945, 1.334)	(1.025, 0.994)	1.017	5.4	0.0913
	M4	(0.159, 0.389)	(0.223, 0.304)	(1.07, 0.977)	1.058	10.3	0.0451
	M5	(0.001, 0.043)	(0.014, 0.02)	(1.189, 0.797)	1.118	38.5	0.0106

We want to know a little more about the distribution of the error.

We use a Pareto Chart: the bars tell us how many (frequency) matchups are within a given Abs % error. We accumulate the frequency and normalize by the number of samples to give us the cumulative frequency, *red line*. (ex. Unity gain at 5% error: 4 samples/52 = 8% likewise at 10% error: 7 + 4/52 = 21%, and so on through the error.

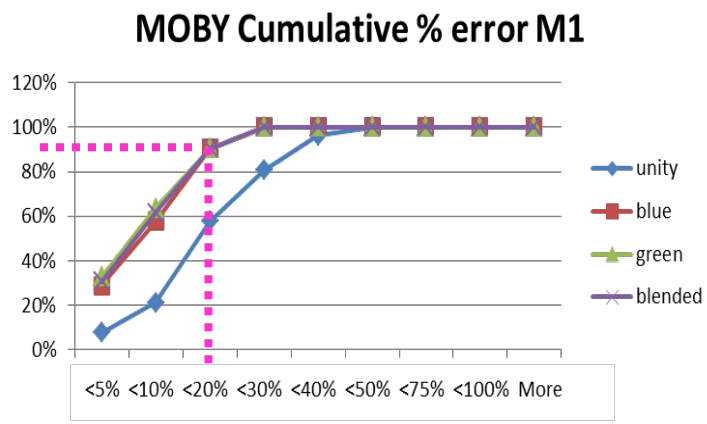


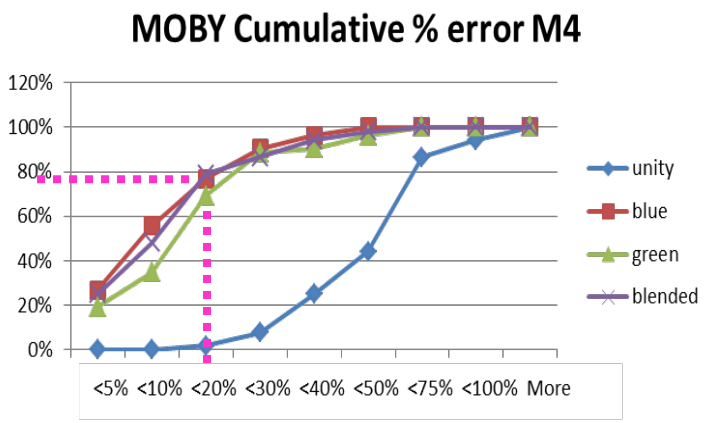
Unity calibration – M1 - 58% of the data has less than 20% error.

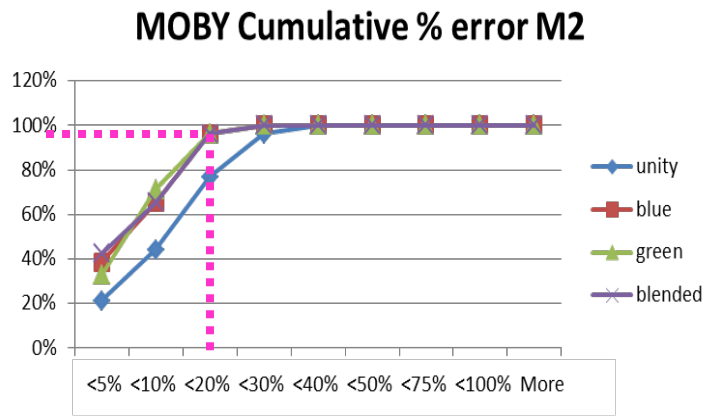


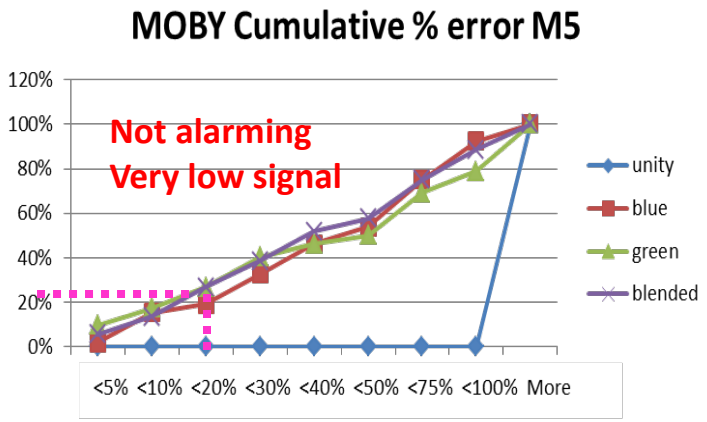
Standard blue water calibration – M1 - 90% of the data has less than 20% error.

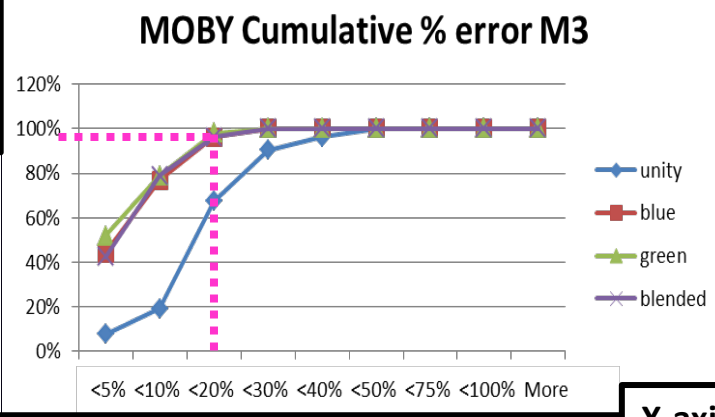
y-axis = Cumulative Frequency (%) in data set









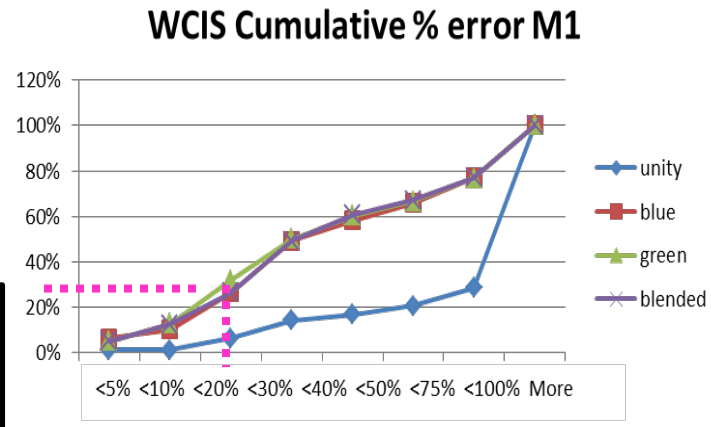


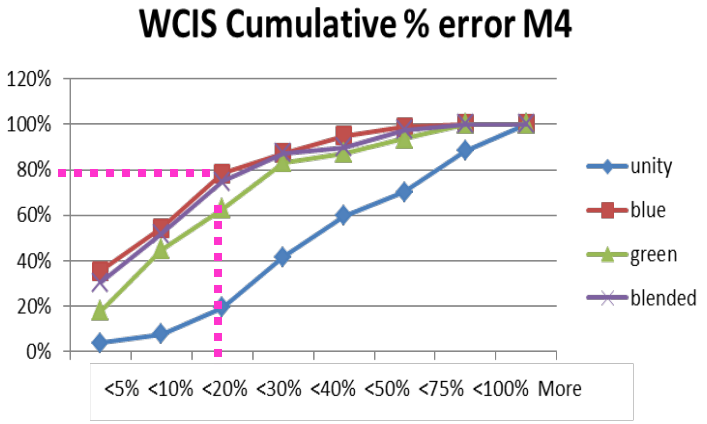
- Any calibration is better than none (unity).
- Blue and blended calibration coefficients produce the best results over all wavelengths.

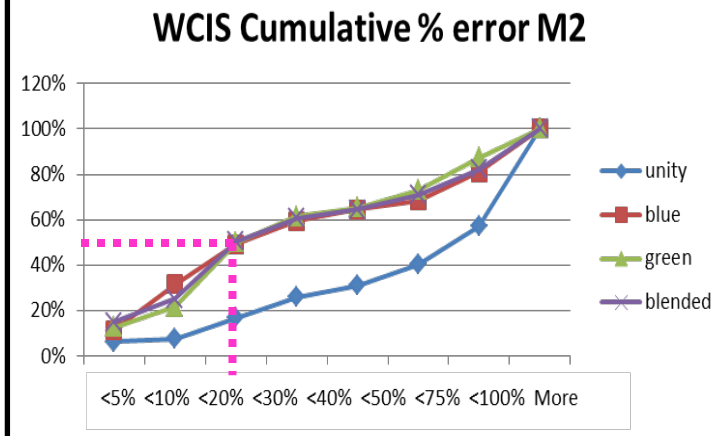
- N = 52

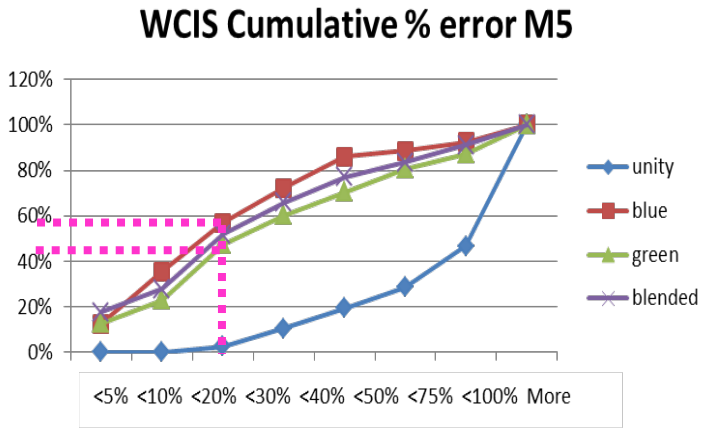
X-axis = Abs.% error

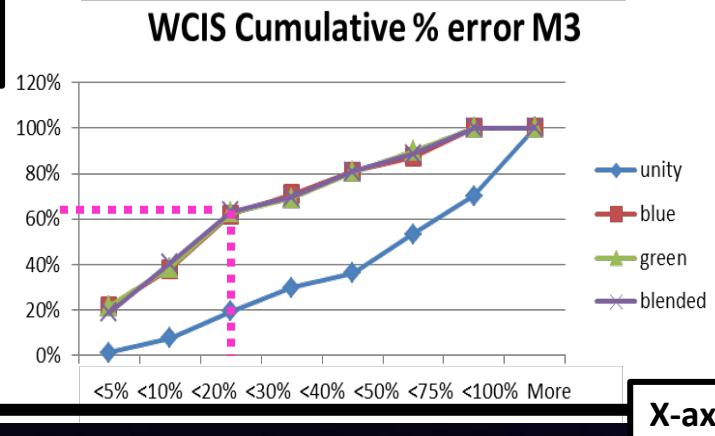
y-axis = Frequency (%) in data set









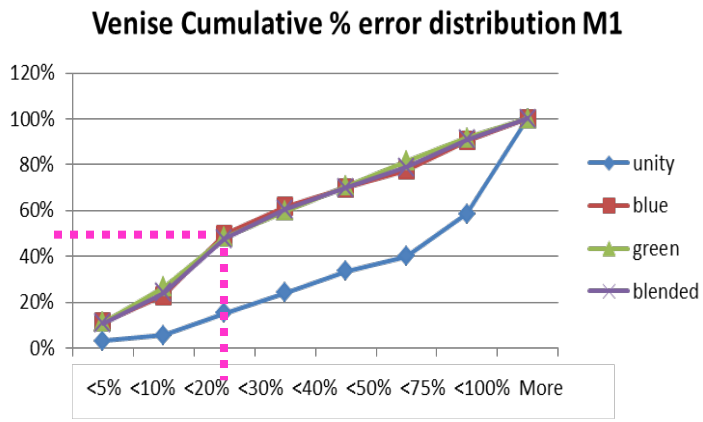


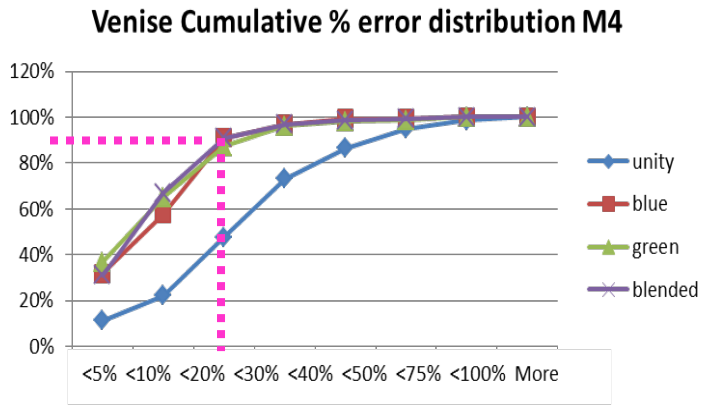
- Any calibration is better than none (unity).
- Blue and blended calibration coefficients produce the best results over all wavelengths.

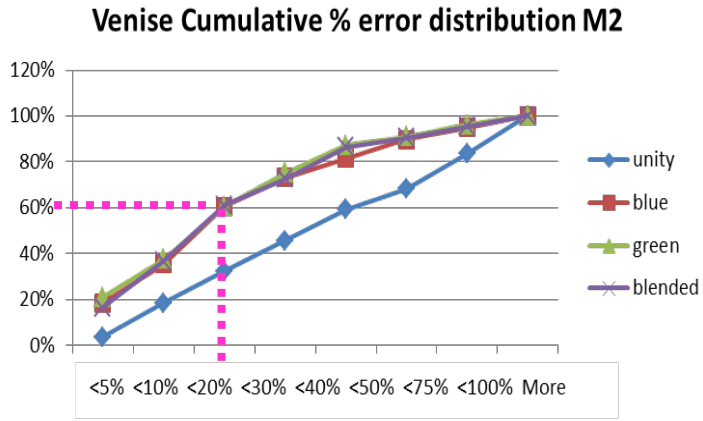
- N = 77

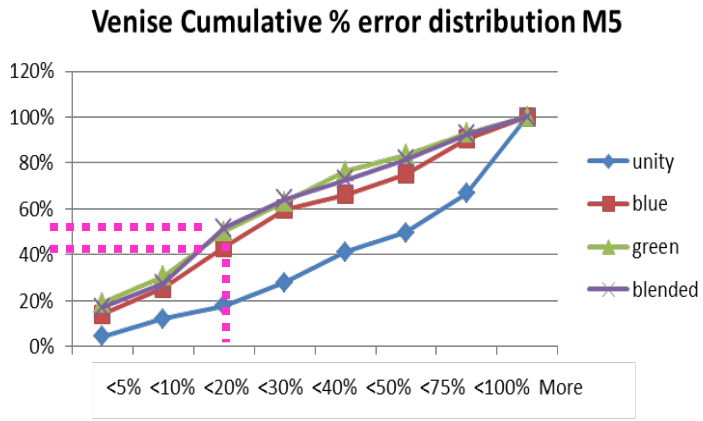
X-axis = Abs.% error

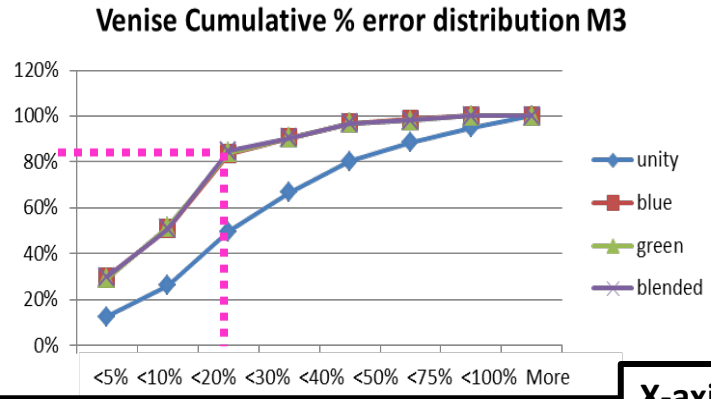
y-axis = Frequency (%) in data set











- Any calibration is better than none (unity).
- Green and blended calibration coefficients produce the best results over all wavelengths.

- N = 157

X-axis = Abs.% error

CONCLUSIONS:

- The OBPG standard methodology using MOBY data provides the most stable calibration.

- We demonstrated the ability to supplement traditional blue water matchups with high quality AERONET-OC green water matchups to derive calibration coefficients without significantly affecting the error distribution of nLw retrievals.

- With new sensors launching, this methodology can be used to support real-time operations and speed up the transition process for new sensors coming online.

ACKNOWLDEGEMENTS:

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