



ships4sst

shipborne radiometers for sea surface temperature

Sentinel-3 SLSTR SST Validation using a Fiducial Reference Measurements (FRM) Service

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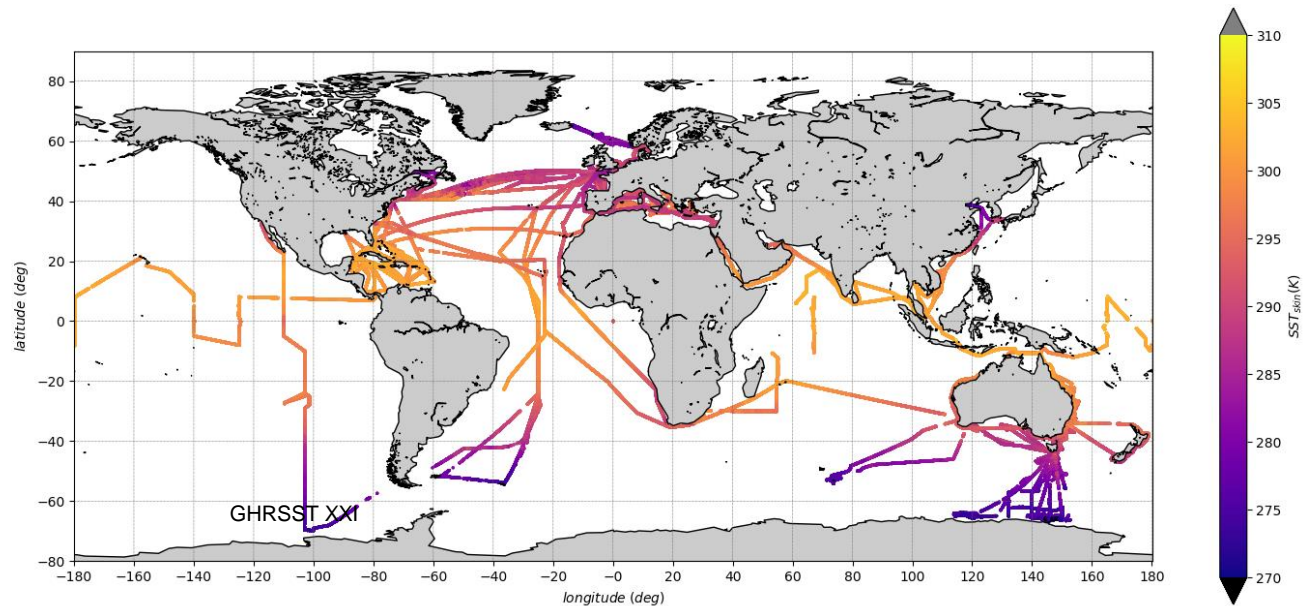
With contributions from: A. Lee, G. Dybkjær, R. Holmes, J.F. Piolle, I. Tomazic

Outline

- Introduction
 - Data sources
 - Validation methods
- Validation Results
 - Reprocessed data 2016 -2018 – global
 - QI results – reprocessed data 2016-2018 – global
 - D3, D2, N3, N2 results for the reprocessed data 2016-2018 – global
- Conclusion
- Appendix
 - NRT validation results, 2018

Data

- SLSTR
 - Reprocessed data: 2016-2018 v006 r1i1
 - NRT data 2018 onwards
- FRM
 - Radiometer data from ships4sst
- The MDB files are produced by Felyx
 - SLSTR L1b and L2 data within 400x400 pixels of matchup
 - L2R data within 6hrs of matchup



ships4sst: FRM4SST

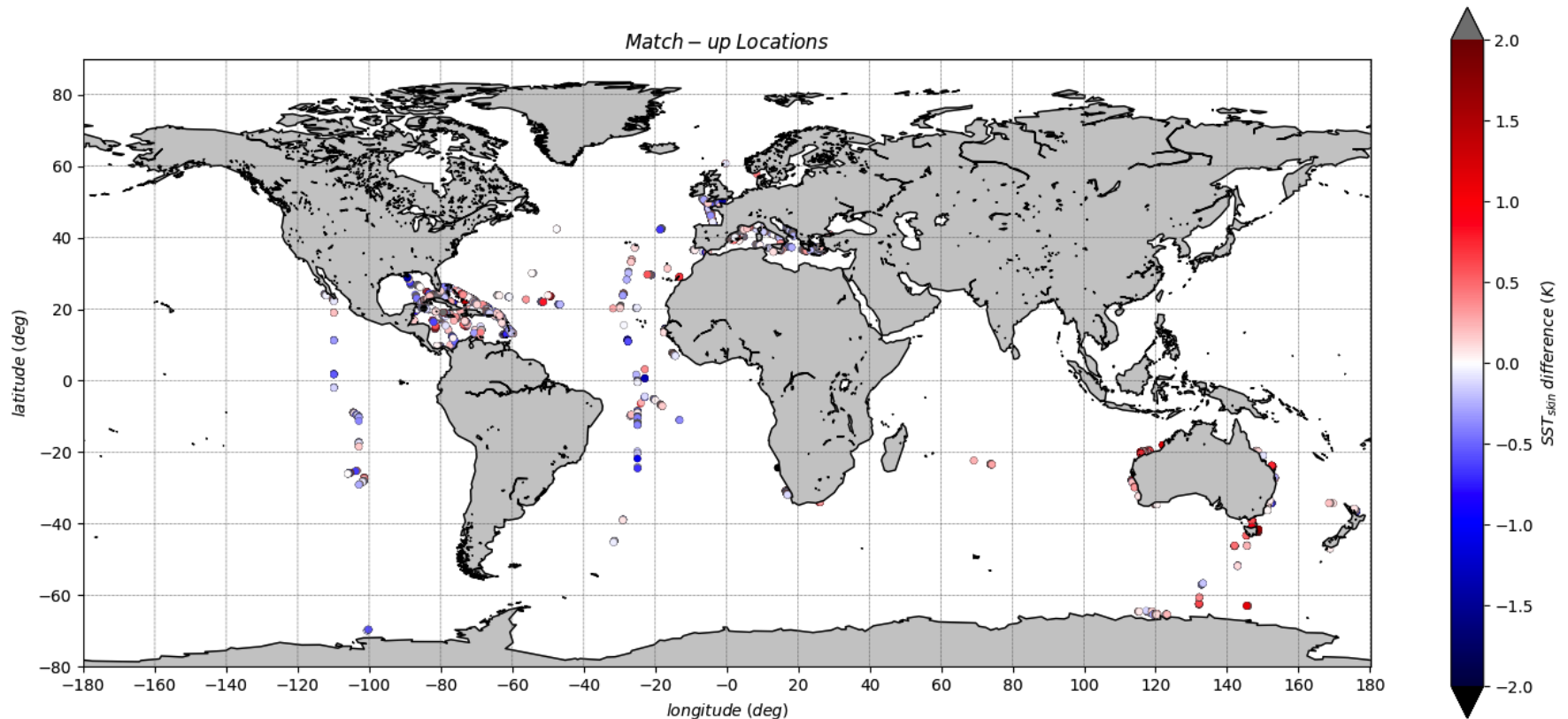
Validation methods

- MDB files (as produced by felyx) are reprocessed
 - allow multiple matches per match-up location (overpass)
 - Validate WST, D3, D2, N3, N2 and all GHRSSST CV levels (0, 3,4,5)
 - follow the Wimmer et.al. 2012 approach.
 - Quality indicator method developed for AATSR used on SLSTR
- Wimmer et. al. 2012:
 - Matchup grades

grade	temporal (h)	spatial (km)
1	0.5	1
2a	0.5	20
2b	2.0	1
3	2.0	20
4	6.0	25

Validation results - global

- WST - August 2016 – April 2018, grade 2b

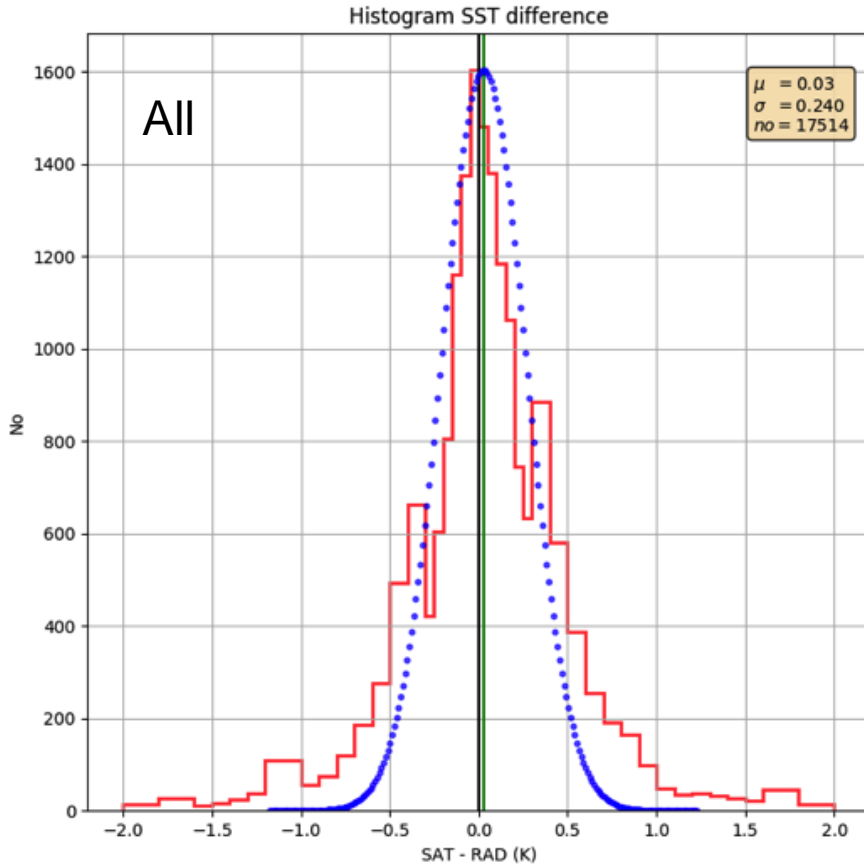


s4sstr11l, all, sstdiff_sst_wst, grade 2b, all, ghrsst-all, qi-all - HuberT

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Validation results – histograms - all

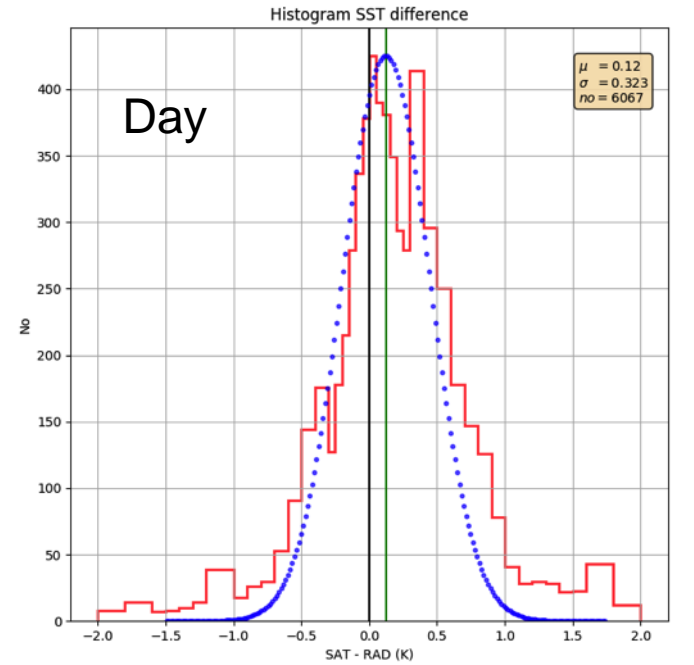
2016 -2018



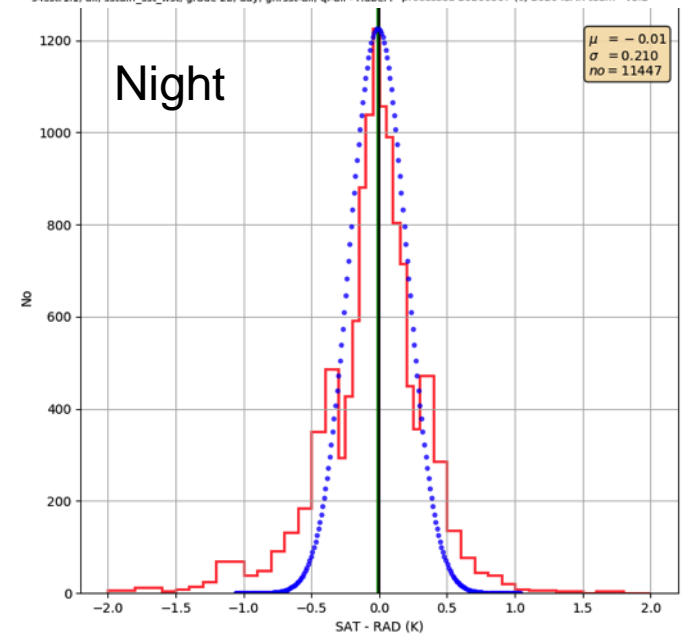
s4sstr1i1, all, sstdiff_sst_wst, grade 2b, all, ghrsst-all, qi-all - HuberT processed 20200507 (c) 2020 ISAR team - v5.2

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GHRSSST XXI



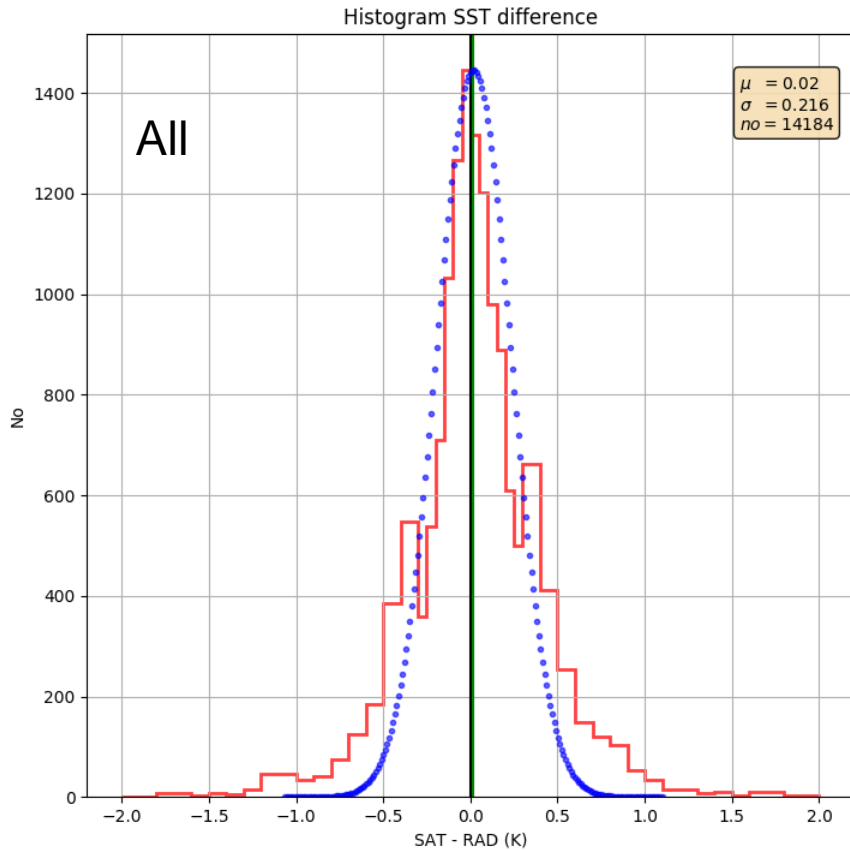
s4sstr1i1, all, sstdiff_sst_wst, grade 2b, day, ghrsst-all, qi-all - HuberT processed 20200507 (c) 2020 ISAR team - v5.2



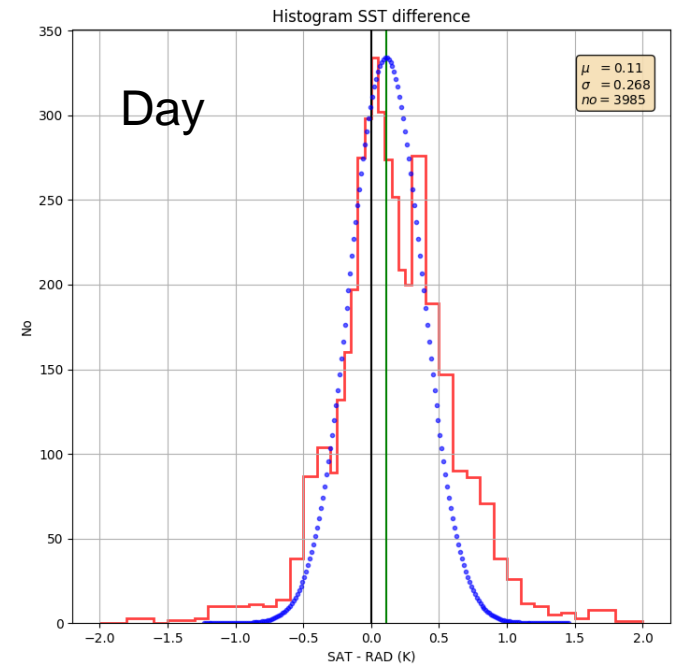
s4sstr1i1, all, sstdiff_sst_wst, grade 2b, night, ghrsst-all, qi-all - HuberT processed 20200507 (c) 2020 ISAR team - v5.2

Histograms – CV5

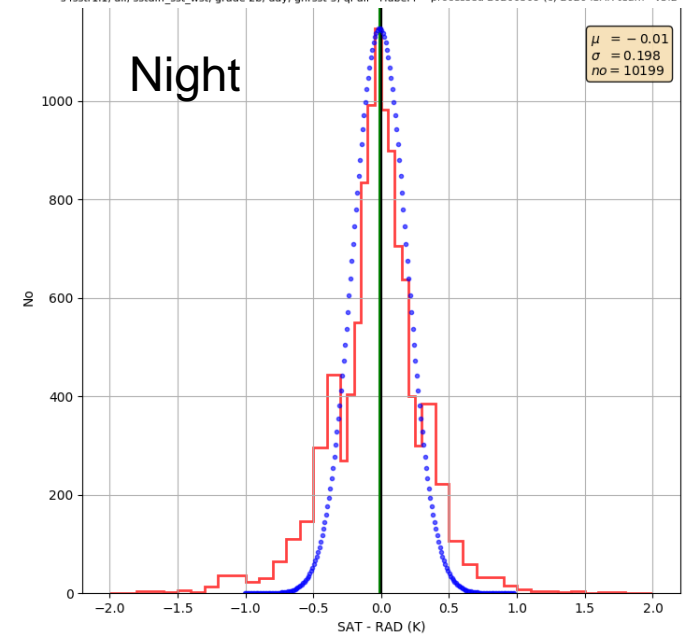
2016 -2018



s4sstr1i1, all, sstdiff_sst_wst, grade 2b, all, ghrsst-5, qi-all - HuberT processed 20200507 (c) 2020 ISAR team - v5.2



s4sstr1i1, all, sstdiff_sst_wst, grade 2b, day, ghrsst-5, qi-all - HuberT processed 20200509 (c) 2020 ISAR team - v5.2



s4sstr1i1, all, sstdiff_sst_wst, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20200509 (c) 2020 ISAR team - v5.2

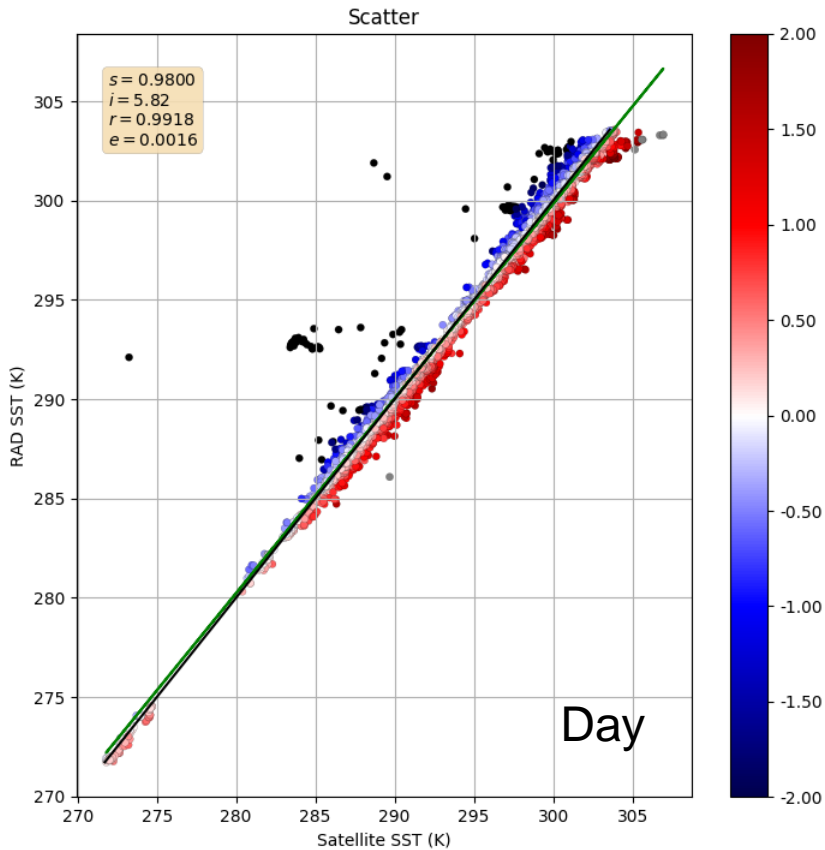
ships4sst: FRM4SST

GHRSSST XXI

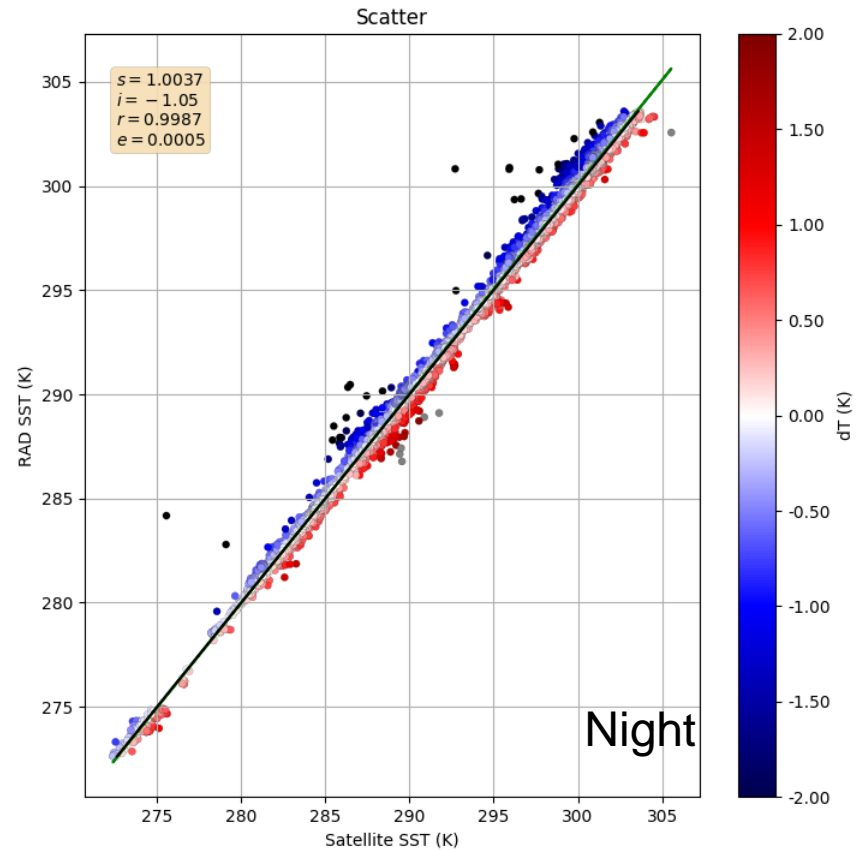


Validation scatter – all

2016 -2018



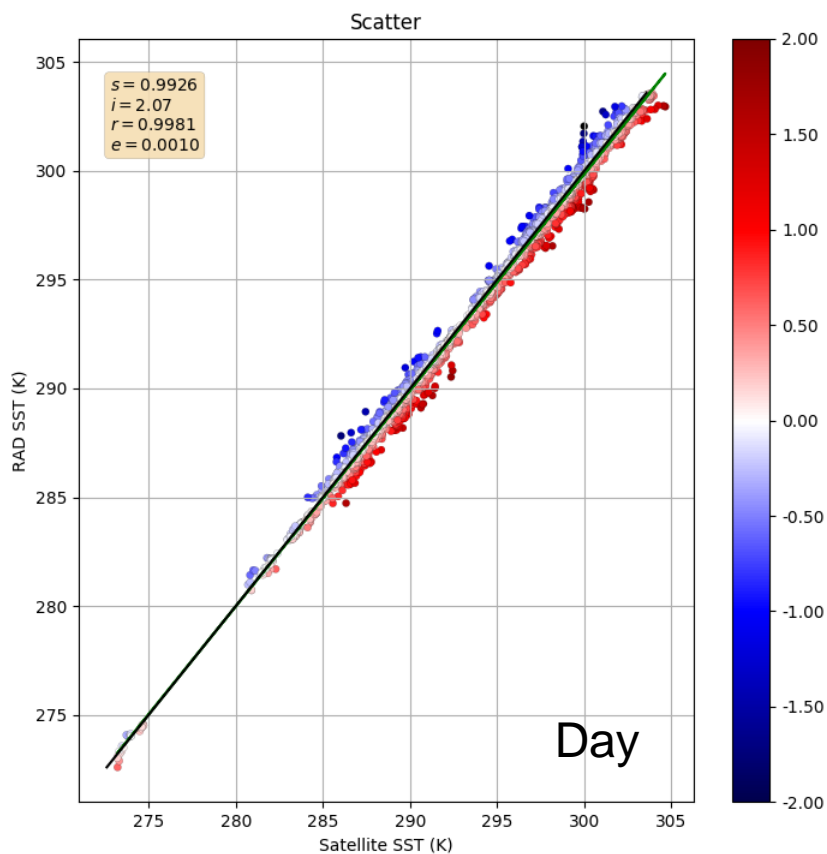
s4sstr11, all, sstdiff_sst_wst, grade 2b, day, ghrsst-all, qi-all - HuberT processed 20200507 (c) 2020 ISAR team - v5.2



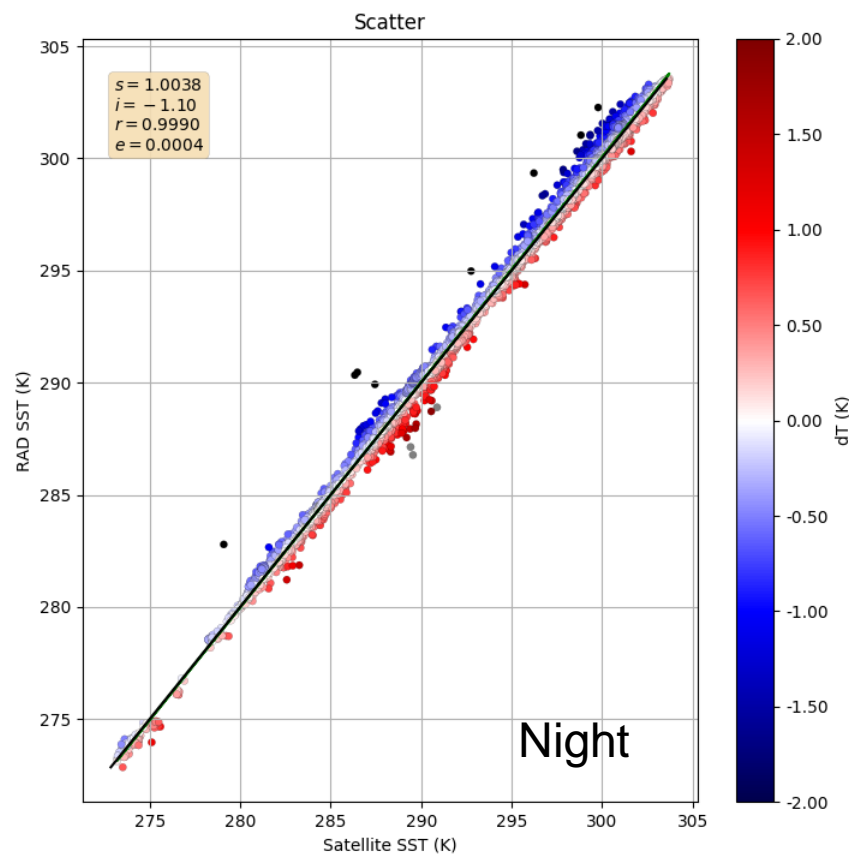
s4sstr11, all, sstdiff_sst_wst, grade 2b, night, ghrsst-all, qi-all - HuberTprocessed 20200507 (c) 2020 ISAR team - v5.2

Validation – scatter, CV 5

2016 -2018



s4sstr11, all, sstdiff_sst_wst, grade 2b, day, ghrsst-5, qi-all - HuberT processed 20200507 (c) 2020 ISAR team - v5.2



s4sstr11, all, sstdiff_sst_wst, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20200507 (c) 2020 ISAR team - v5.2

Validation results – statistics

- 2016 -2018: All data

Day						
Grade	MDiff	RSD	No	Overpass	Min Temp	Max Temp
1	0.12	0.28	1521	193	271.95	304.30
2a	0.11	0.40	4888	367	270.48	307.29
2b	0.12	0.32	6067	318	271.80	306.95
3	0.12	0.43	18663	458	270.20	307.34
4	0.09	0.50	54823	643	270.20	307.48

WST						
ALL						
Grade	MDiff	RSD	No	Overpass	Min Temp	Max Temp
1	0.03	0.22	4518	542	271.95	304.30
2a	0.04	0.32	12548	967	270.48	307.29
2b	0.03	0.24	17514	819	271.80	306.95
3	0.04	0.33	48138	1161	270.20	307.34
4	0.03	0.38	132206	1475	270.20	307.48

Night						
Grade	MDiff	RSD	No	Overpass	Min Temp	Max Temp
1	-0.01	0.20	2997	349	272.38	304.28
2a	0.00	0.27	7660	600	271.80	304.68
2b	-0.01	0.21	11447	501	272.38	305.55
3	0.00	0.28	29475	703	271.30	305.55
4	0.00	0.31	77383	832	271.30	305.55

Validation results – statistics

- 2016 -2018: CV5

Day							
Grade	MDiff	RSD	No	Overpass	Min Temp	Max Temp	
1	0.10	0.24	1046	139	273.25	303.90	
2a	0.15	0.32	2821	248	273.16	303.94	
2b	0.11	0.27	3985	233	273.19	304.66	
3	0.16	0.35	10565	332	273.16	304.66	
4	0.13	0.42	31538	505	273.15	304.66	

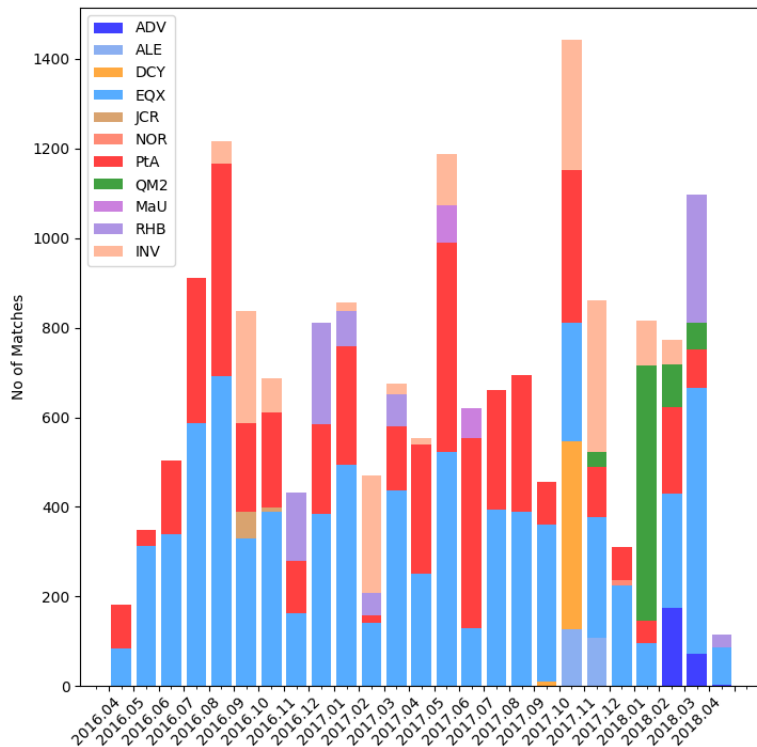
WST							
ALL							
Grade	MDiff	RSD	No	Overpass	Min Temp	Max Temp	
1	0.02	0.20	3696	456	273.20	303.90	
2a	0.05	0.27	9375	783	273.16	303.94	
2b	0.02	0.22	14184	690	273.19	304.66	
3	0.04	0.28	35744	971	273.15	304.78	
4	0.04	0.33	97827	1289	273.15	305.05	

Night							
Grade	MDiff	RSD	No	Overpass	Min Temp	Max Temp	
1	-0.01	0.19	2650	317	273.20	303.71	
2a	0.01	0.25	6554	535	273.16	303.71	
2b	-0.01	0.20	10199	457	273.20	303.71	
3	0.00	0.26	25179	639	273.15	304.78	
4	0.01	0.29	66289	784	273.15	305.05	

Validation results – RDAC split

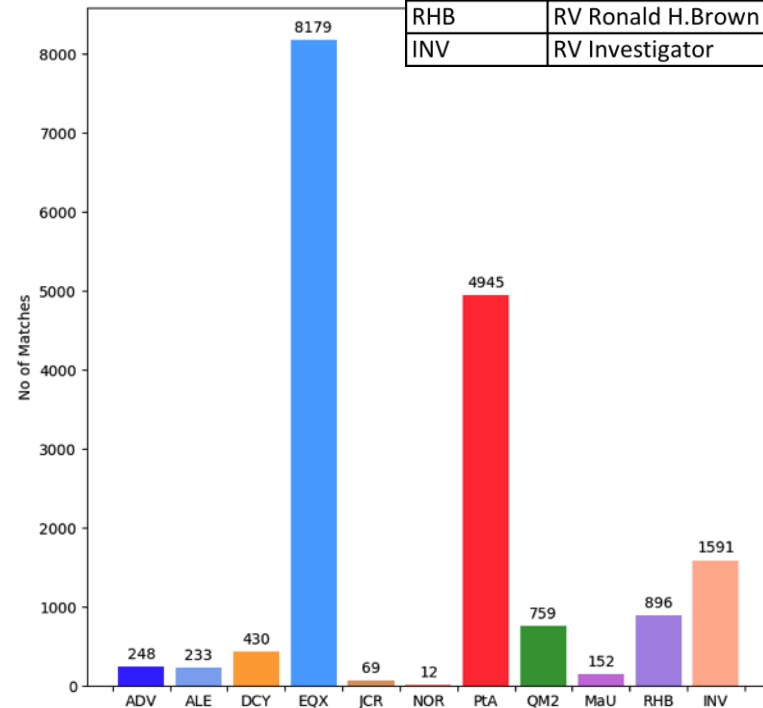
- 2016-2018

Abbreviation	Ships name	Operator
ADV	MV Adventure of the Seas	RSMAS
ALE	MV Allure of the Seas	RSMAS
DCY	RRS Discovery	UoS
EQX	MV Celebrity Equinox	RSMAS
JCR	RRS James Clark Ross	UoS
NOR	M/V Norrana	DMI
PtA	MV Pont Aven	UoS
QM2	MV Queen Mary 2	RAL
MaU	RV Minerva Uno	RSMAS
RHB	RV Ronald H. Brown	RSMAS
INV	RV Investigator	CSIRO



all, sstdiff_sst_wst, grade 2b, all, ghrsst-all, qi-all - HuberT

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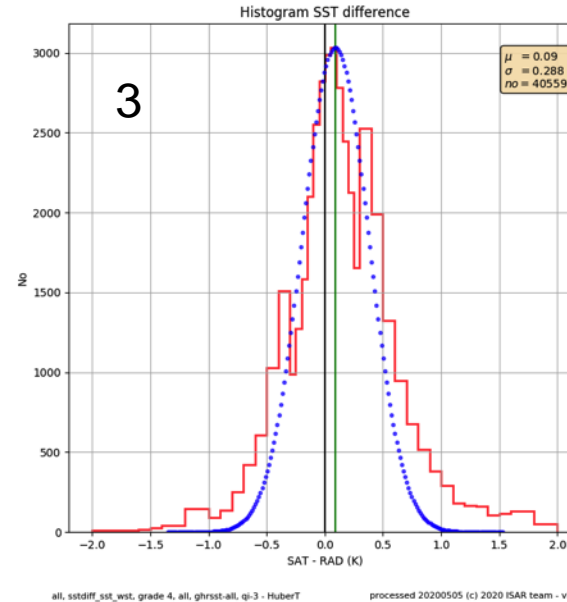
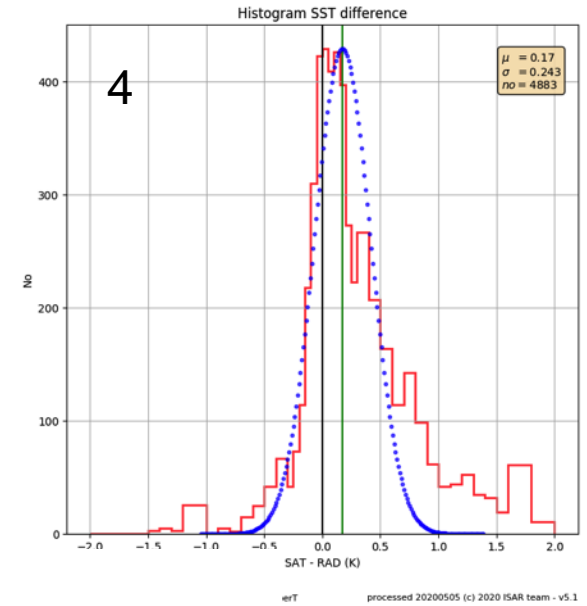
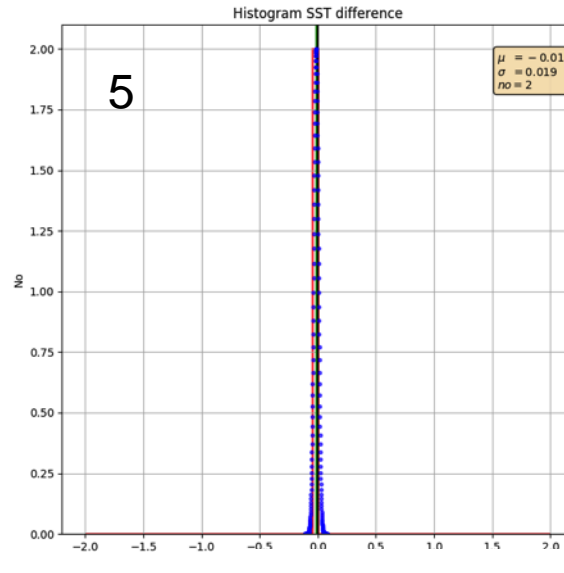
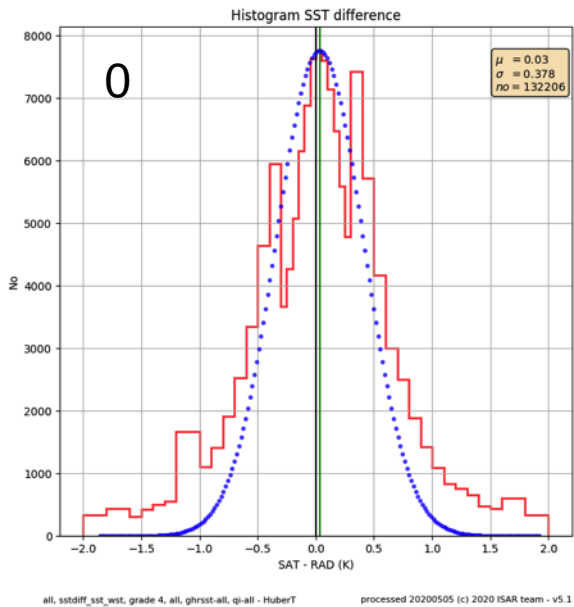
all, sstdiff_sst_wst, grade 2b, all, ghrsst-all, qi-all - HuberT

processed 20200505 (c) 2020 ISAR team - v5.1

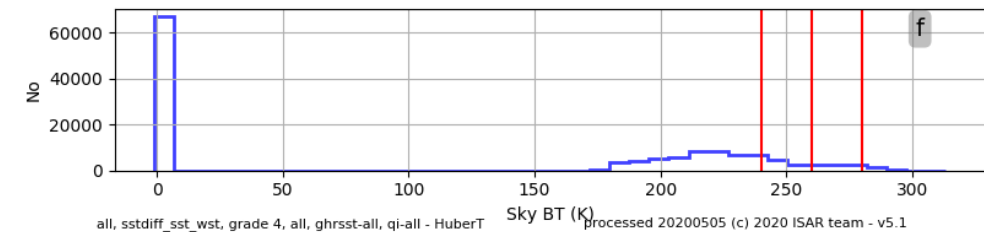
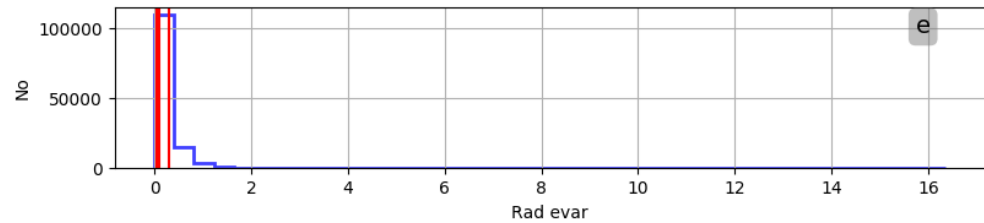
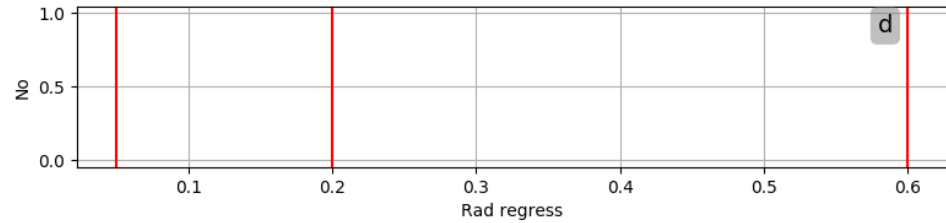
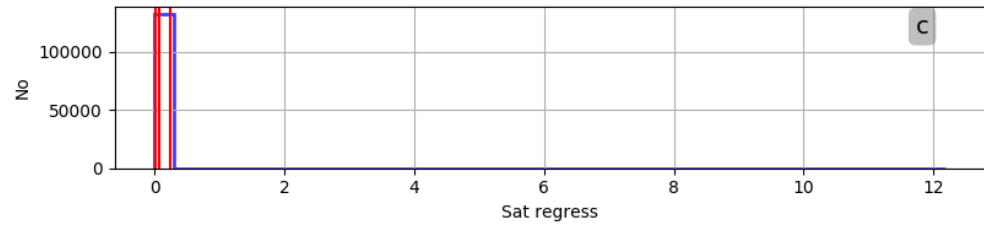
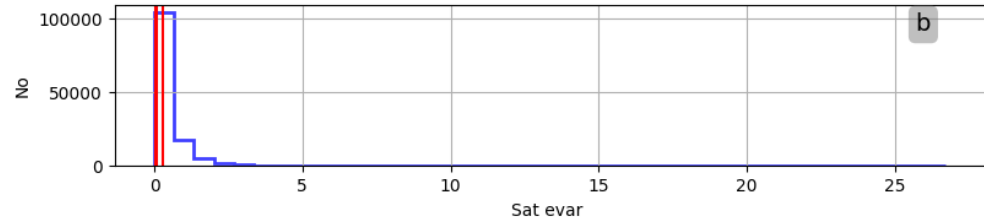
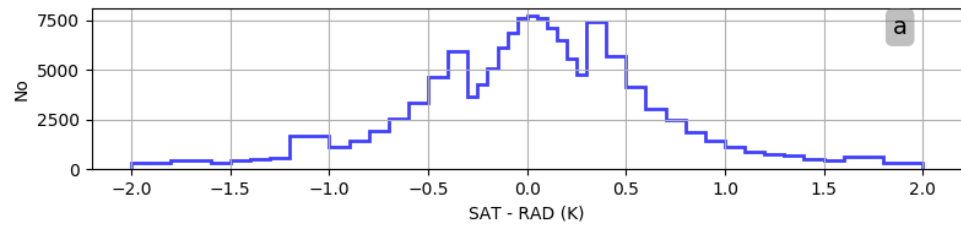
Validation results - QI

- Estimateing match-up uncertainty :
 - $\sigma = \sigma_S + \sigma_T + \sigma_M + \sigma_P + \sigma_Z$
 - $\sigma = \sigma_S + \sigma_T + (\sigma_{PS} + \sigma_{PR})$
- Reprocessed data - August 2016 – April 2018
- Five indicators:
 - Satellite variability – de-trended 9x9 field around match, weighted with chi2 to allow for cloudy pixels
 - Satellite trend – 2d trend
 - Radiometer variability de-trended track data, 2 h either side of match, weighted with chi2 to allow for missing data.
 - Radiometer Trend
 - Radiometer Sky BT
 - Not everybody provides this data
 - Only run on grade 4 (QI 0 is grade 4)
 - Uses 4 levels (0, 3, 4, 5)

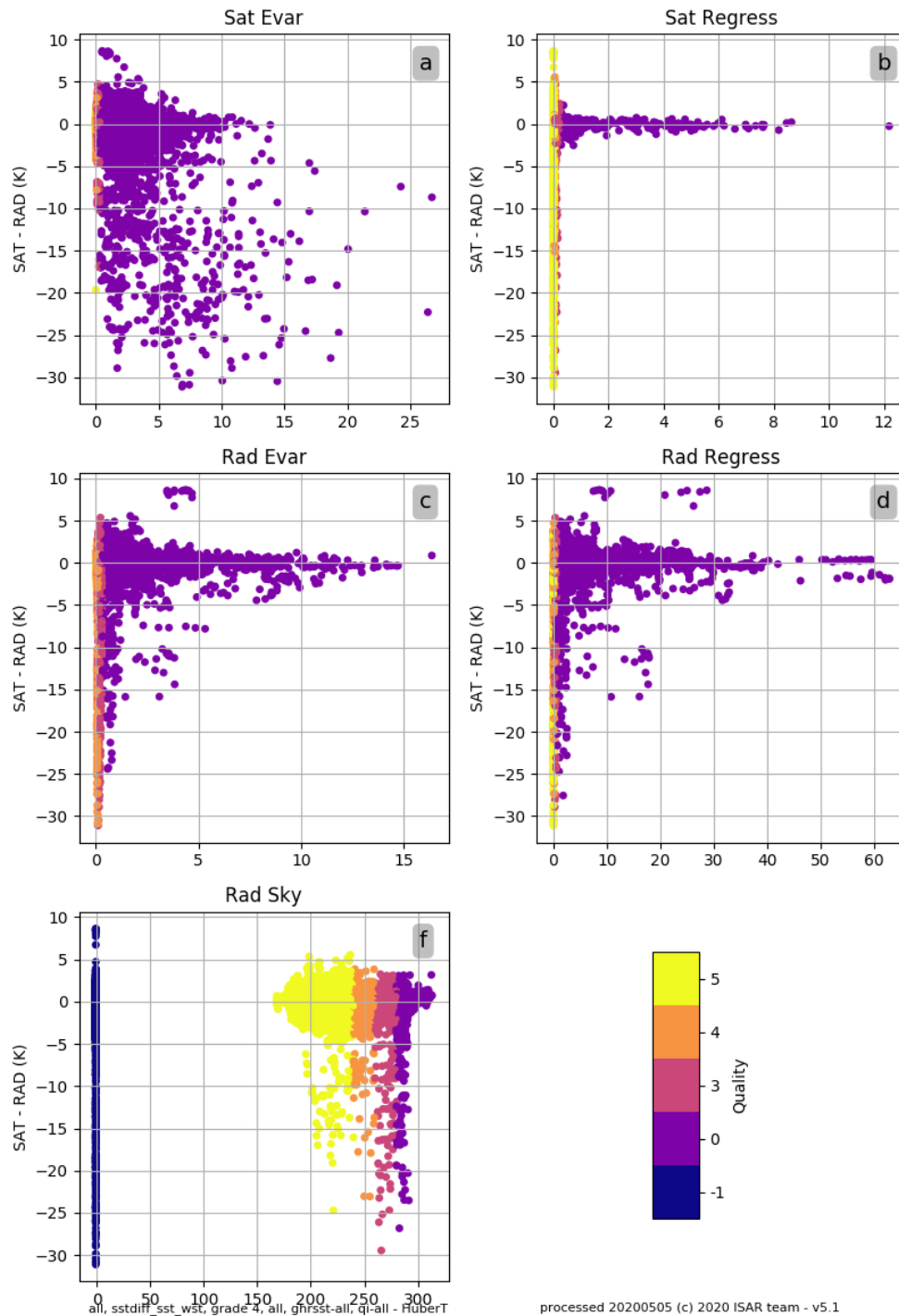
Validation results – Q1 histograms



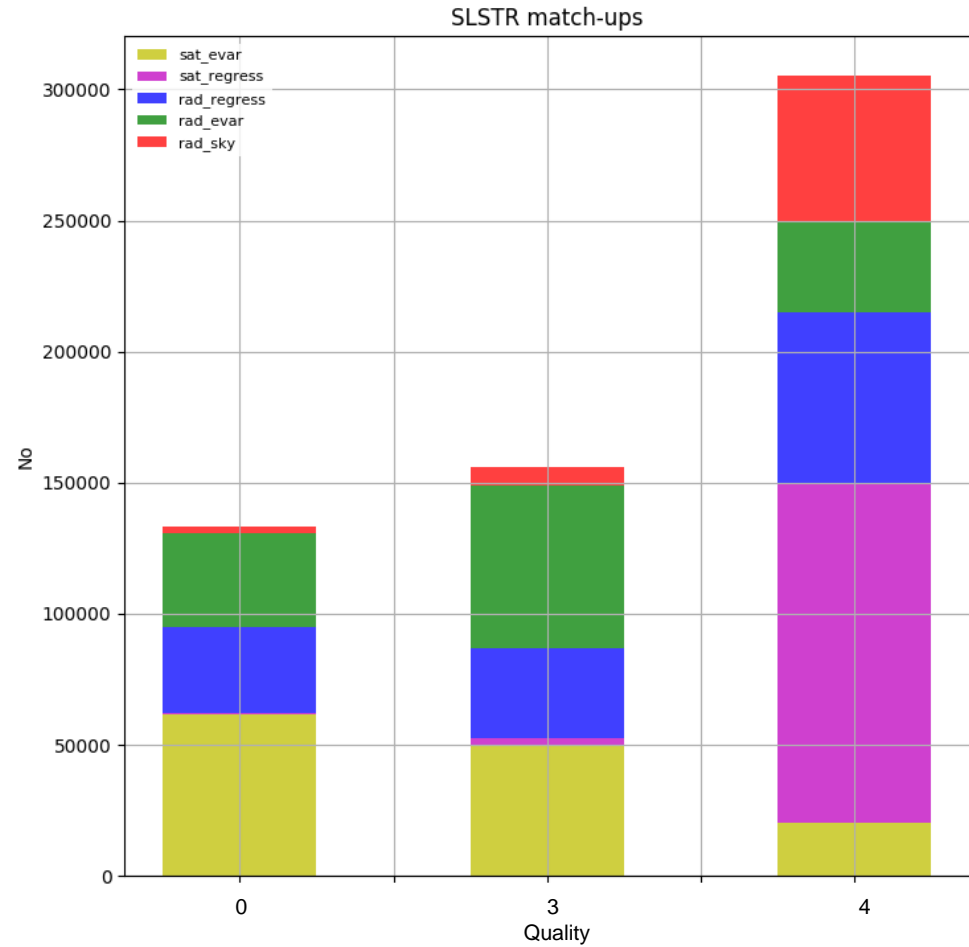
Histograms – Q1



Validation scatter – QI



Validation – Q1



all, sstdiff_sst_wst, grade 4, all, ghrsst-all, qi-all - HuberT

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Validation results – statistics

- 2016- 2018 - QI

Day							
QI	MDiff	RSD	No	Overpass	Min Temp	Max Temp	
0	0.09	0.50	54823	643	270.20	307.48	
3	0.17	0.40	17244	401	271.78	304.24	
4	0.37	0.49	2056	117	273.65	304.07	
5							

WST							
All							
QI	MDiff	RSD	No	Overpass	Min Temp	Max Temp	
0	0.03	0.38	132206	1475	270.20	307.48	
3	0.09	0.29	40559	994	271.65	304.54	
4	0.17	0.24	4883	278	273.65	304.07	
5	-0.01	0.02	2	1	296.79	296.79	

Night							
QI	MDiff	RSD	No	Overpass	Min Temp	Max Temp	
0	0.00	0.31	77383	832	271.30	305.55	
3	0.04	0.23	23315	593	271.65	304.54	
4	0.09	0.17	2827	161	274.12	303.50	
5	-0.01	0.02	2	1	296.79	296.79	

Validation results – D3,D2,N3,N2 - all

- 2016 – 2018, all, CV5, D3, N3 excluded in day time

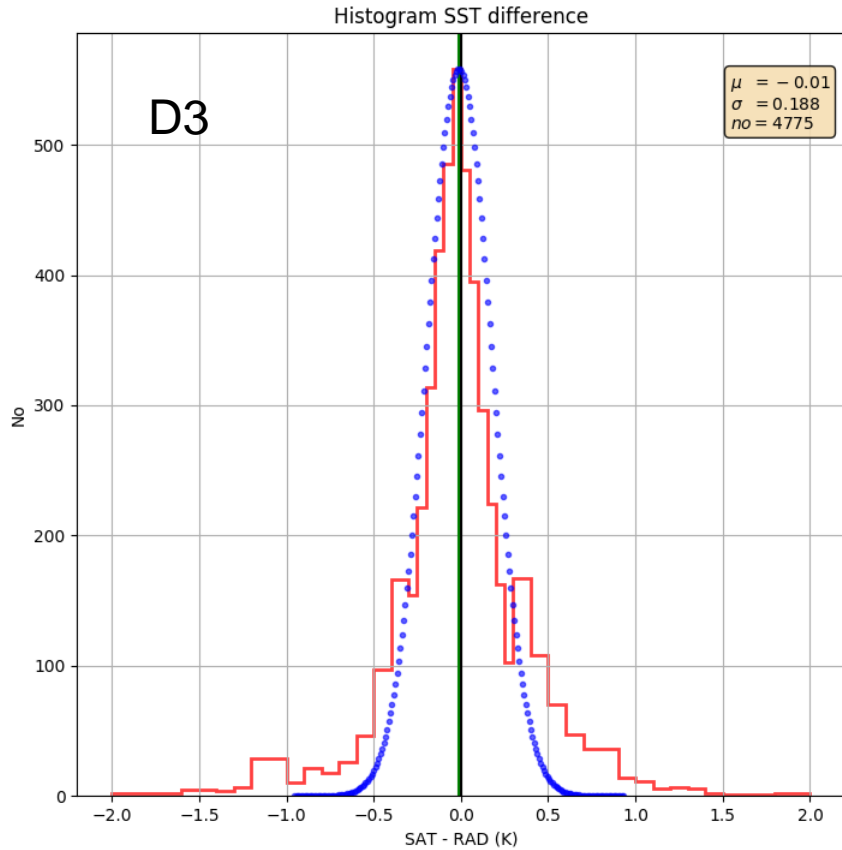
D3							N3						
Night							Night						
Grade	MDiff	RSD	No	Overpass	Min Temp	Max Temp	Grade	MDiff	RSD	No	Overpass	Min Temp	Max Temp
1	-0.01	0.18	1339	317	273.20		1	0.02	0.17	1772	317	273.36	303.75
2a	0.02	0.24	3051	535	272.97		2a	0.00	0.24	4535	535	273.00	303.75
2b	-0.01	0.19	4775	457	273.20		2b	0.01	0.18	6739	457	273.36	303.75
3	0.02	0.27	11846	639	272.97		3	0.00	0.24	17482	639	273.00	303.80
4	0.02	0.31	31362	784	272.87		4	0.00	0.27	45864	784	272.74	305.05

D2							N2						
Day							Day						
Grade	MDiff	RSD	No	Overpass	Min Temp	Max Temp	Grade	MDiff	RSD	No	Overpass	Min Temp	Max Temp
1	0.04	0.22	475	139	281.21		1	0.07	0.27	817	139	273.27	304.51
2a	0.09	0.32	1550	248	273.54		2a	0.12	0.38	2342	248	273.16	304.51
2b	0.09	0.28	1921	233	273.62		2b	0.11	0.32	3085	233	273.19	304.51
3	0.10	0.35	5832	332	273.13		3	0.14	0.40	8731	332	273.14	304.51
4	0.09	0.41	17445	505	272.89		4	0.11	0.44	25984	505	273.02	304.77

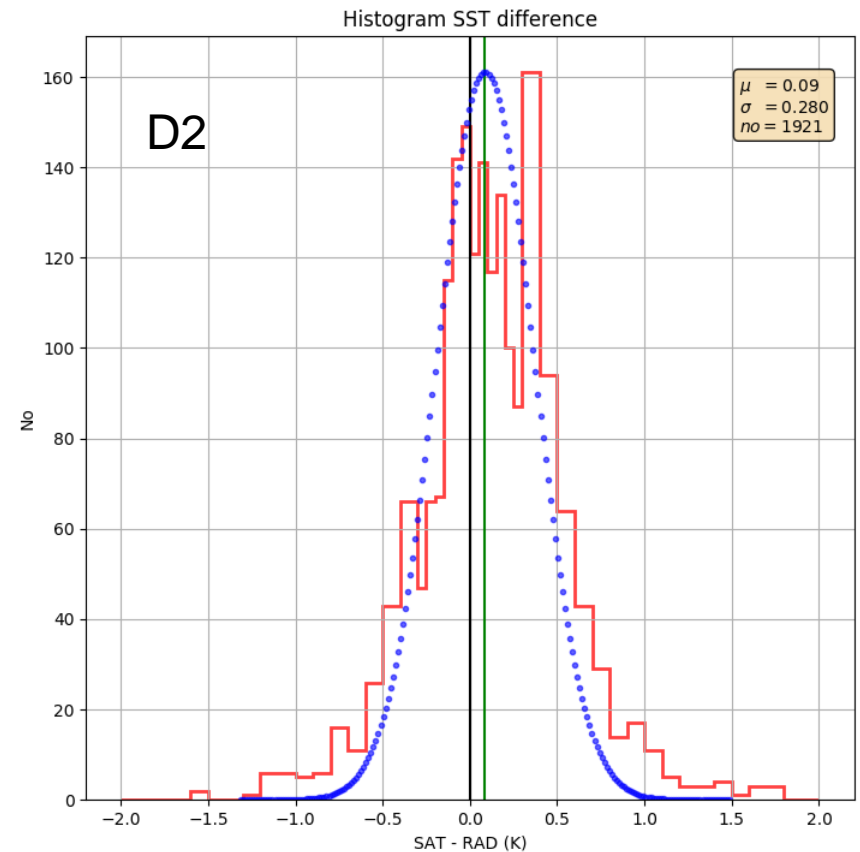
D2							N2						
Night							Night						
Grade	MDiff	RSD	No	Overpass	Min Temp	Max Temp	Grade	MDiff	RSD	No	Overpass	Min Temp	Max Temp
1	0.04	0.23	1339	317	273.16		1	0.07	0.29	1772	317	273.33	304.46
2a	0.05	0.32	3051	535	272.93		2a	0.04	0.39	4535	535	272.99	304.46
2b	0.03	0.24	4775	457	273.01		2b	0.05	0.30	6739	457	273.32	304.53
3	0.05	0.33	11846	639	272.93		3	0.04	0.39	17482	639	272.99	304.53
4	0.06	0.36	31362	784	272.71		4	0.04	0.42	45864	784	272.72	305.73

Validation results – D3,D2

- Grade 2b, CV5, same pixel, night, day



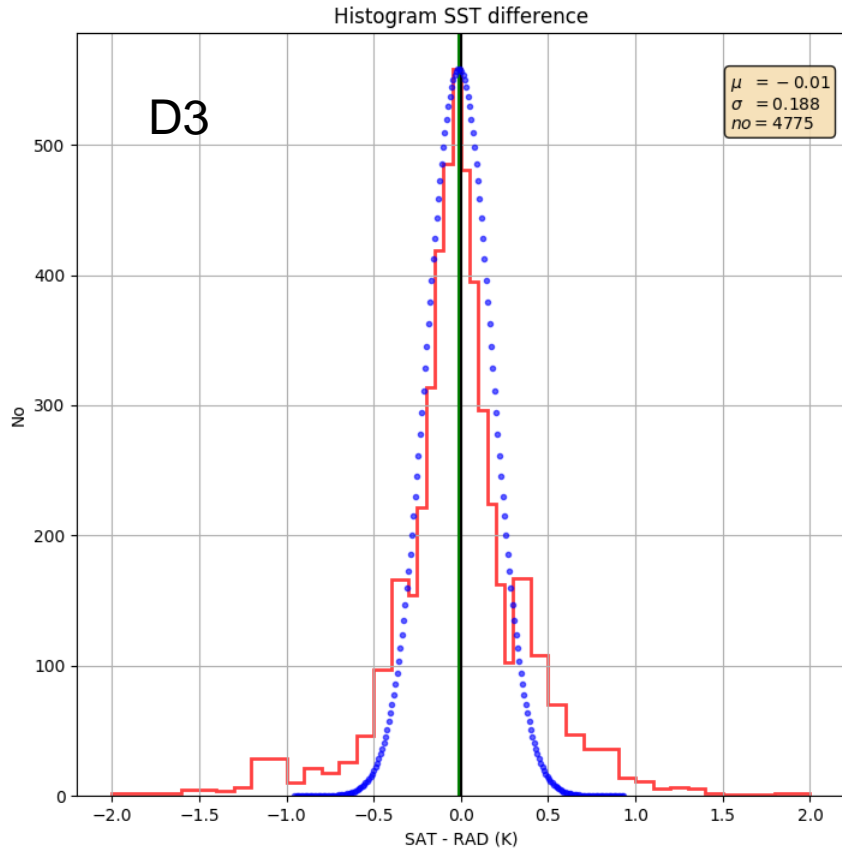
s4sstr1i1, all, sstdiff_D3, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20200509 (c) 2020 ISAR team - v5.2



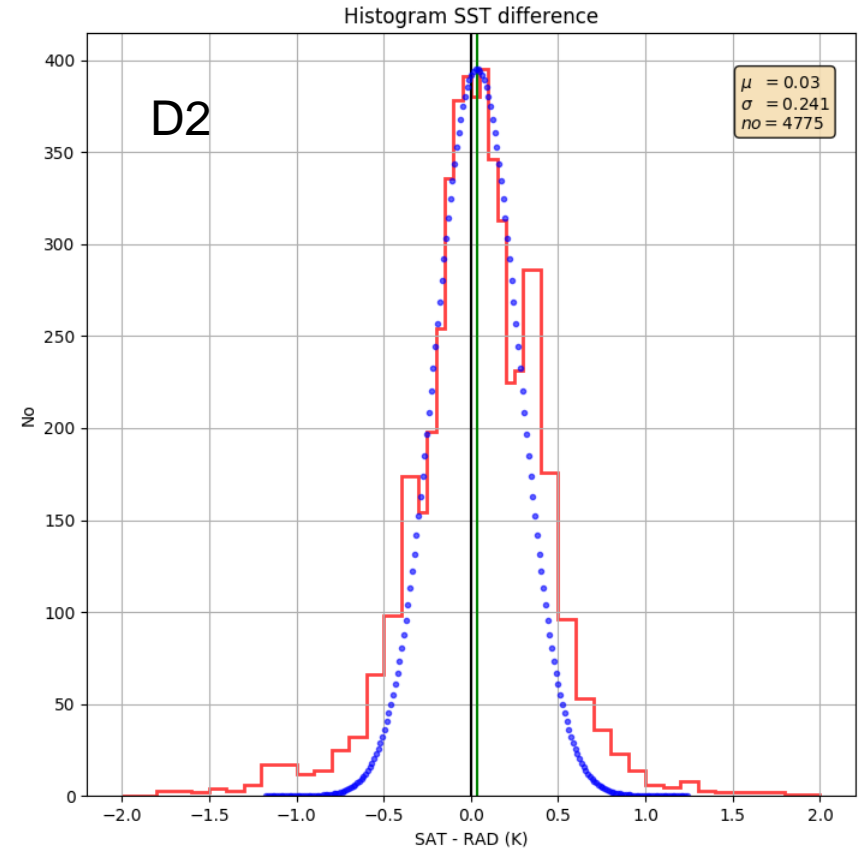
s4sstr1i1, all, sstdiff_D2, grade 2b, day, ghrsst-5, qi-all - HuberT processed 20200509 (c) 2020 ISAR team - v5.2

Validation results – D3,D2

- Grade 2b, CV5, same pixel, both night



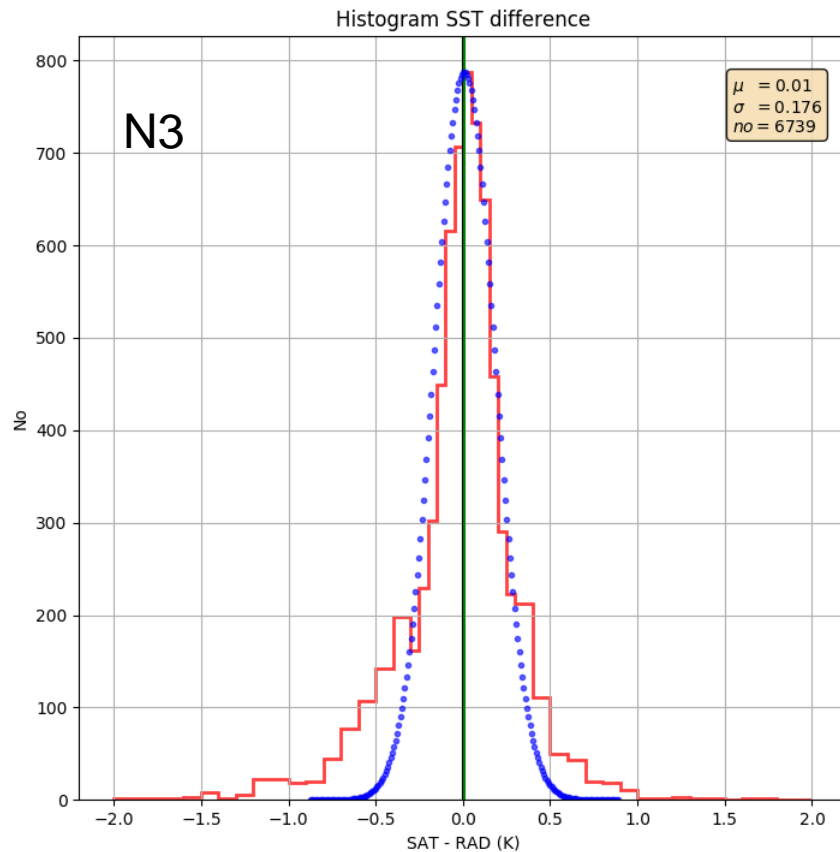
s4sstr111, all, sstdiff_D3, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20200509 (c) 2020 ISAR team - v5.2



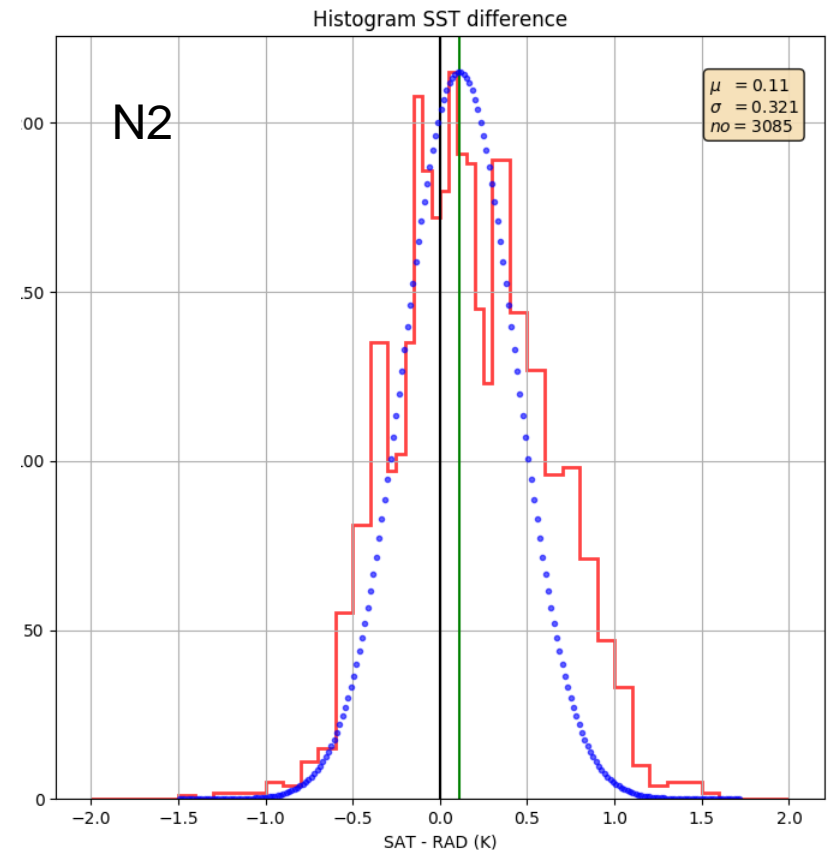
s4sstr111, all, sstdiff_D2, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20200509 (c) 2020 ISAR team - v5.2

Validation results – N3, N2

- Grade 2b, CV5, same pixel, night, day



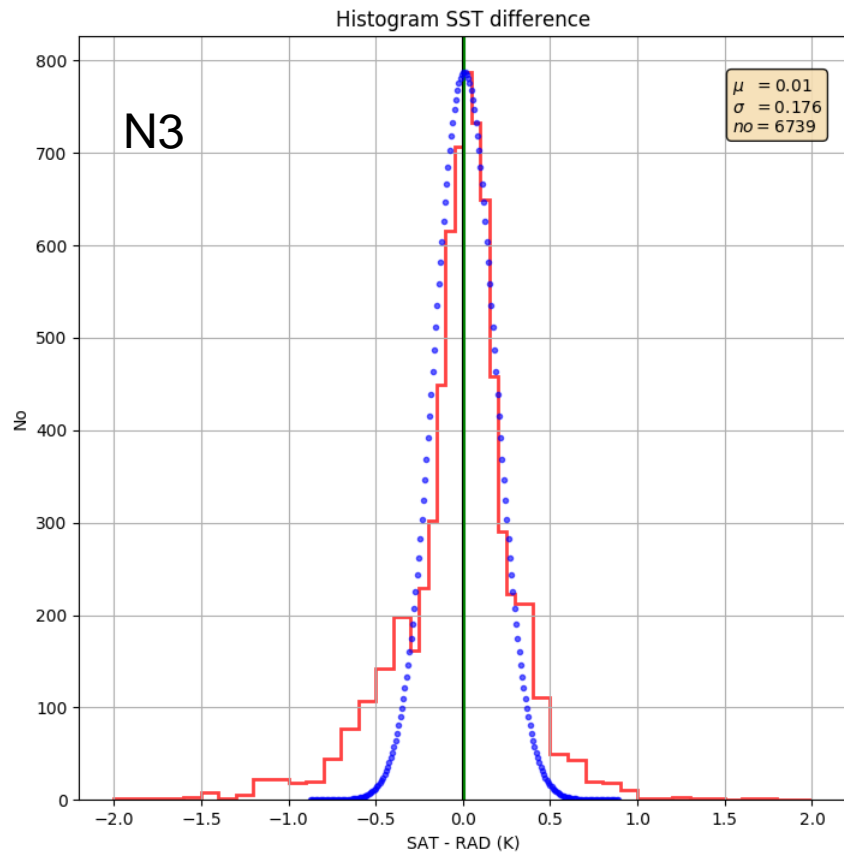
s4sstr1i1, all, sstdiff_N3, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20200509 (c) 2020 ISAR team - v5.2



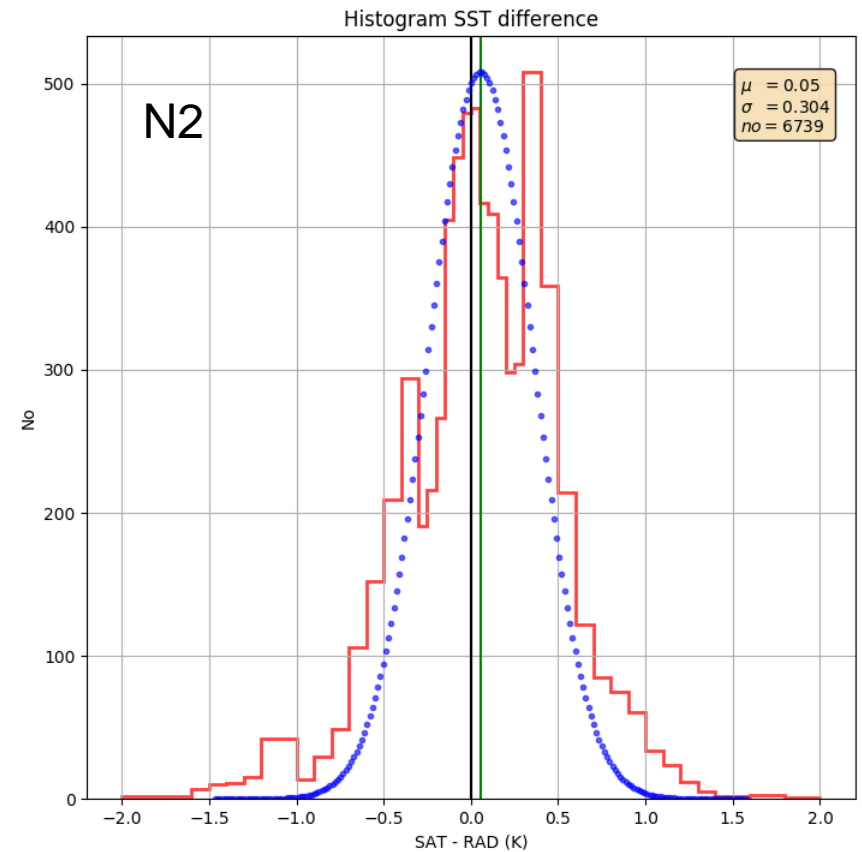
s4sstr1i1, all, sstdiff_N2, grade 2b, day, ghrsst-5, qi-all - HuberT processed 20200509 (c) 2020 ISAR team - v5.2

Validation results – N3, N2

- Grade 2b, CV5, same pixel, both night



s4sstr1i1, all, sstdiff_N3, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20200509 (c) 2020 ISAR team - v5.2



s4sstr1i1, all, sstdiff_N2, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20200509 (c) 2020 ISAR team - v5.2

Conclusions

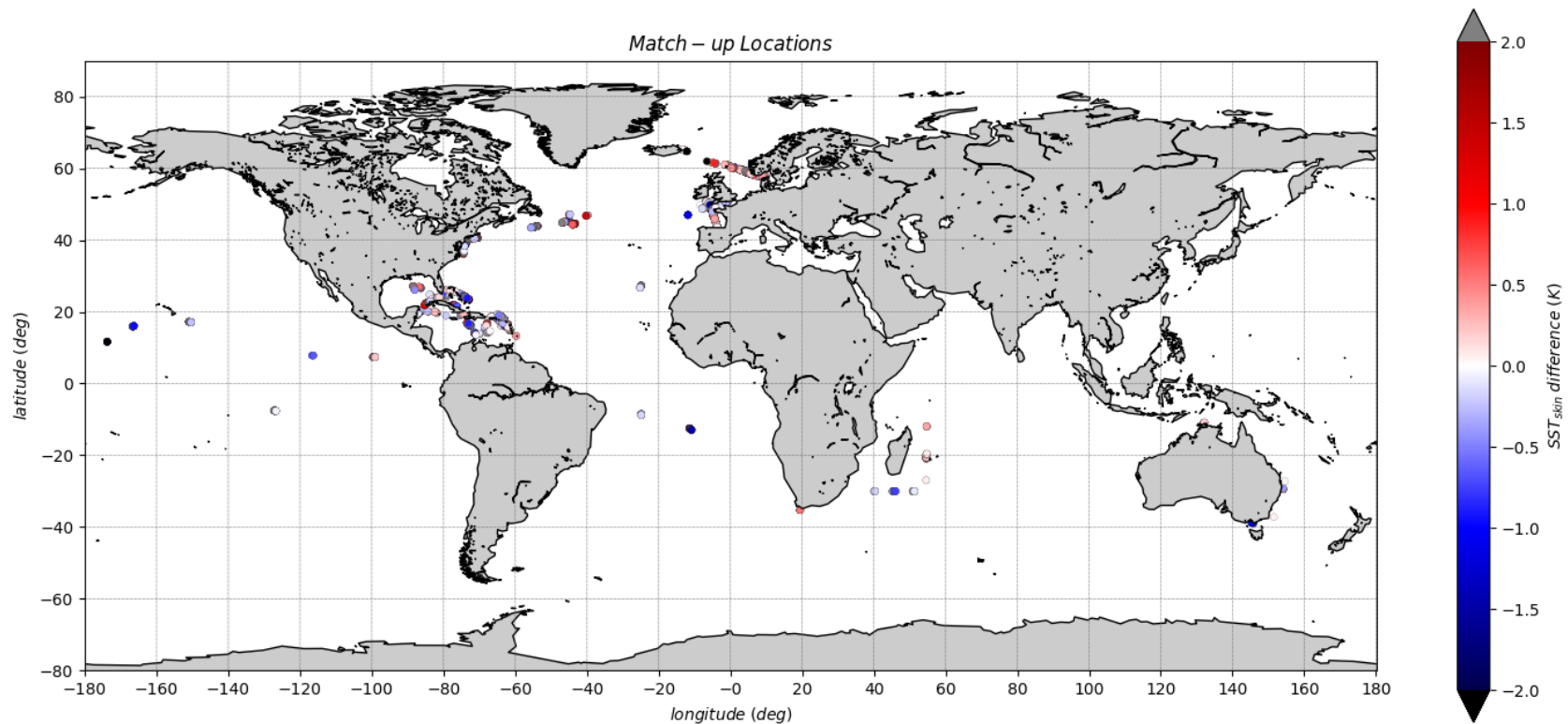
- Validation of SLSTR with FRM data:
 - Shows very good results for SLSTR
 - Virtually no mean difference at night and only a small difference at day time
 - RSD is lower at night than day time and comparable to AATSR .
- QI results
 - Need checking why so few QI 5
 - Need some work to investigate the differences between AATSR and SLSTR results:
 - Thresholds too stringent/wrong for SLSTR?
 - ◆ Developed for one region (English Channel and Bay of Biscay, maybe not applicable globally ?
 - Processing differences?

What else is available

- NRT results for 2018, in appendix
- Results for GHRSSST CV 3 and 4
- Dependence plots for WST, D3, D2, N3 and N2:
 - Latitude, Wind, uncertainty
 - Temporal match-up window
 - Spatial match-up window
- QI method on D3, D2, N3 and N2
- Regional results for each route, split by ships name. They have the same set of statistics and plots as the global results

Validation results - global

- NRT- April 2018 – Dec 2018

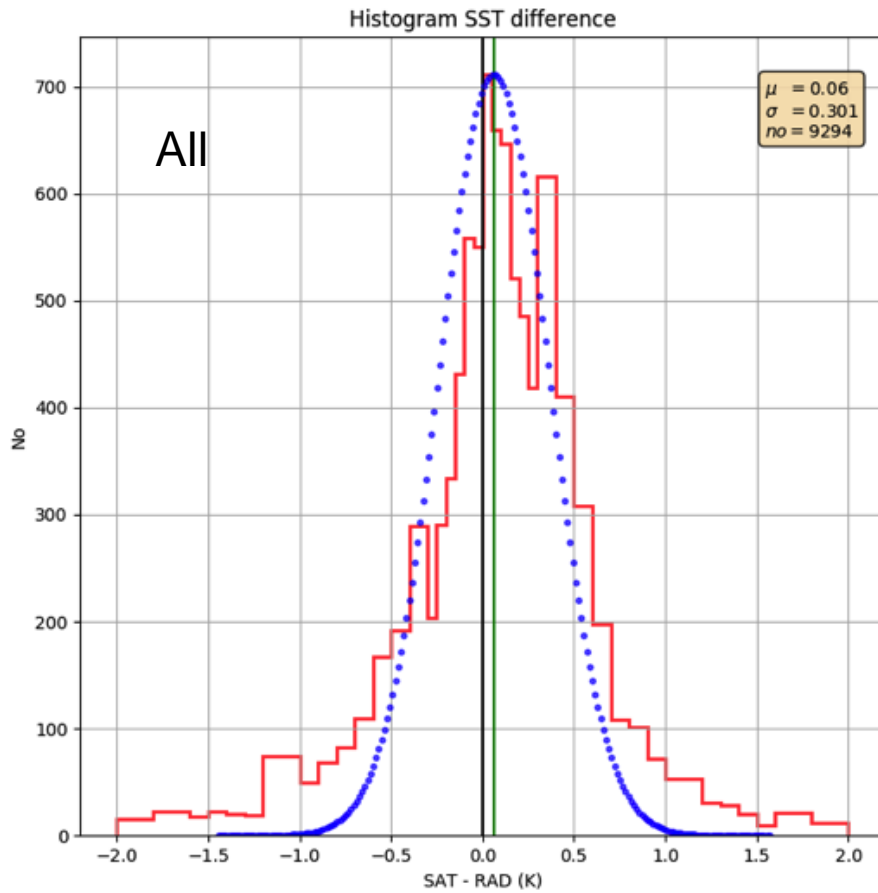


s4sstr1i1, all, sstdiff_sst_wst, grade 2b, all, ghrsst-all, qi-all - HuberT

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Validation results – global histograms

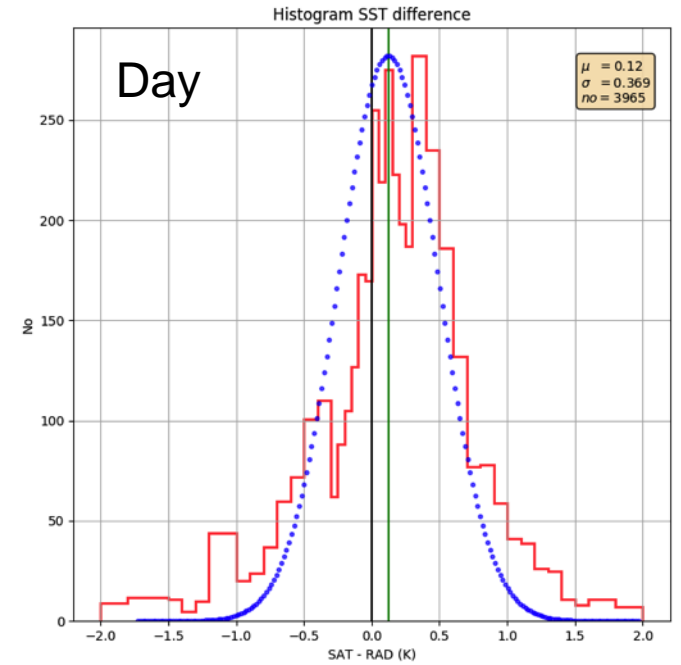
NRT: 2018



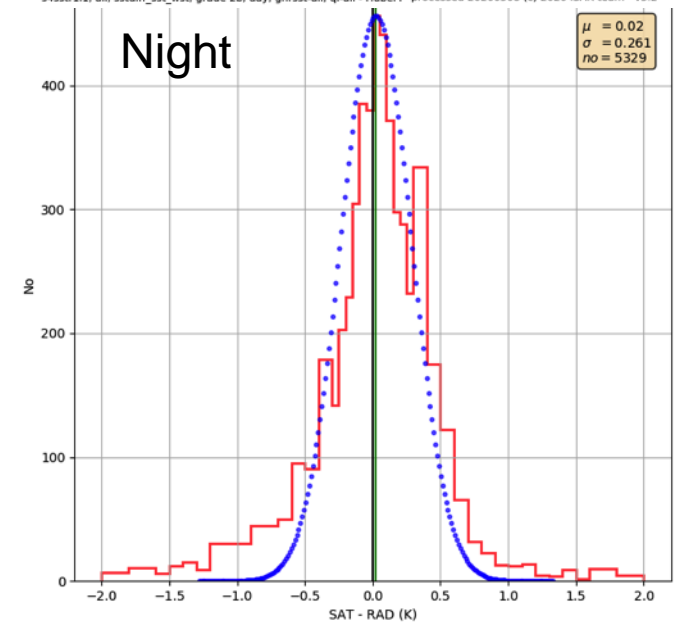
s4sstr1i1, all, sstdiff_sst_wst, grade 2b, all, ghrsst-all, qi-all - HuberT processed 20200508 (c) 2020 ISAR team - v5.2

ships4sst: FRM4SST

GHRSSST XXI



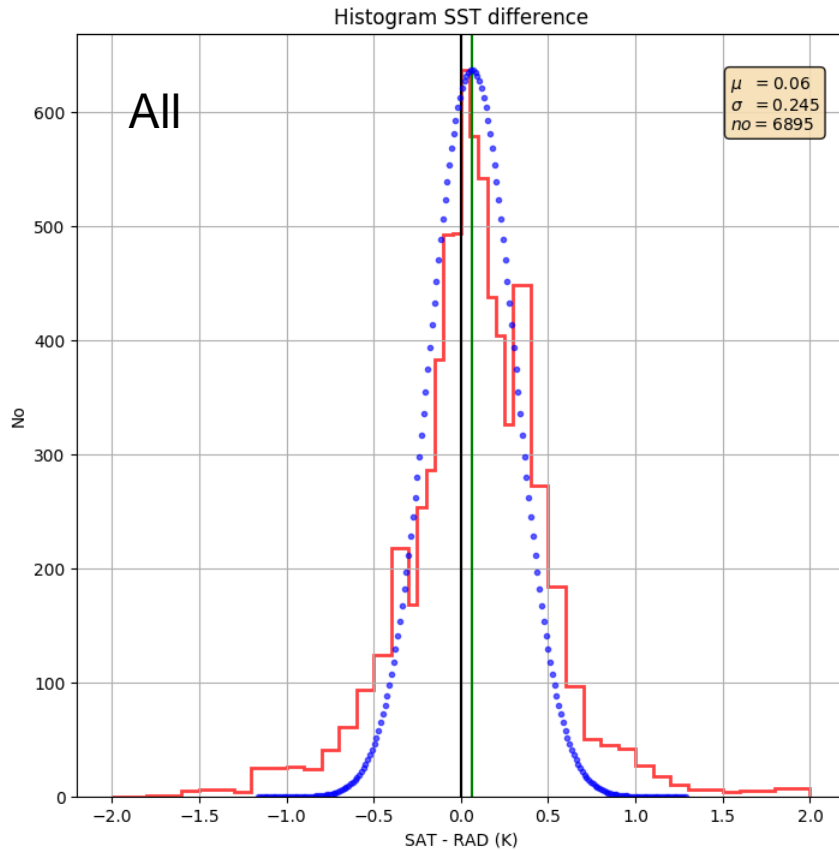
s4sstr1i1, all, sstdiff_sst_wst, grade 2b, day, ghrsst-all, qi-all - HuberT processed 20200508 (c) 2020 ISAR team - v5.2



s4sstr1i1, all, sstdiff_sst_wst, grade 2b, night, ghrsst-all, qi-all - HuberT processed 20200508 (c) 2020 ISAR team - v5.2

Histograms – CV5, All

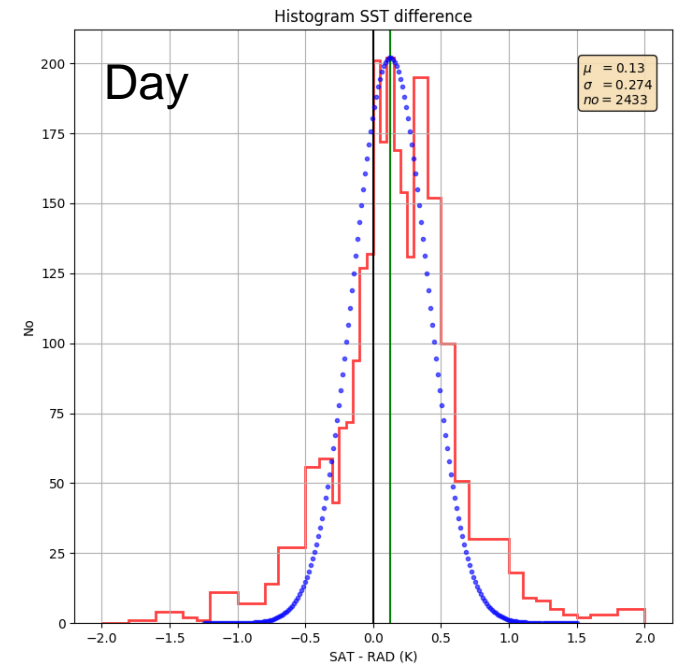
NRT: 2018



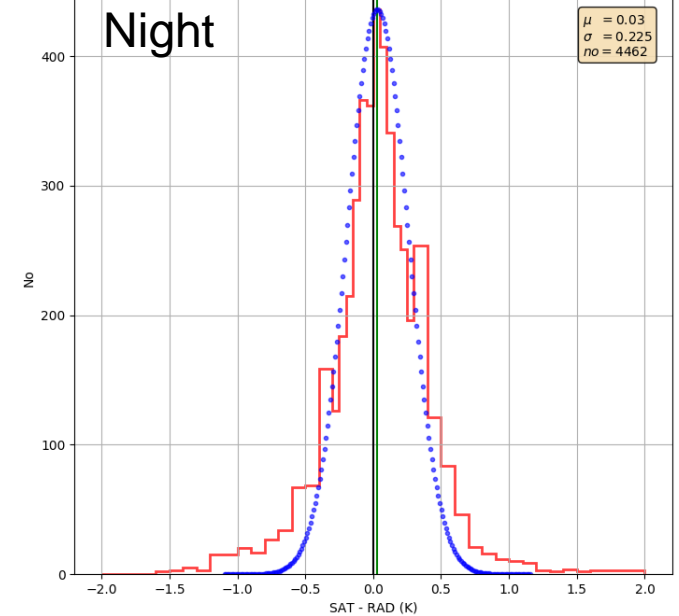
s4sstr1i1, all, sstdiff_sst_wst, grade 2b, all, ghrsst-5, qi-all - HuberT processed 20200511 (c) 2020 ISAR team - v5.2

ships4sst: FRM4SST

GHRSSST XXI



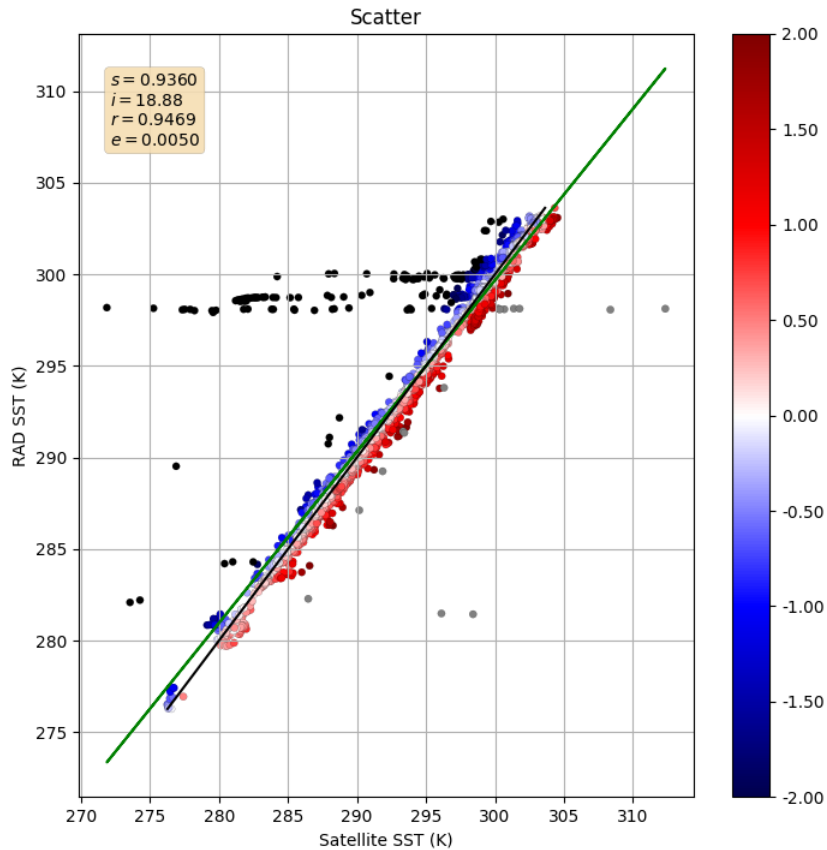
s4sstr1i1, all, sstdiff_sst_wst, grade 2b, day, ghrsst-5, qi-all - HuberT processed 20200508 (c) 2020 ISAR team - v5.2



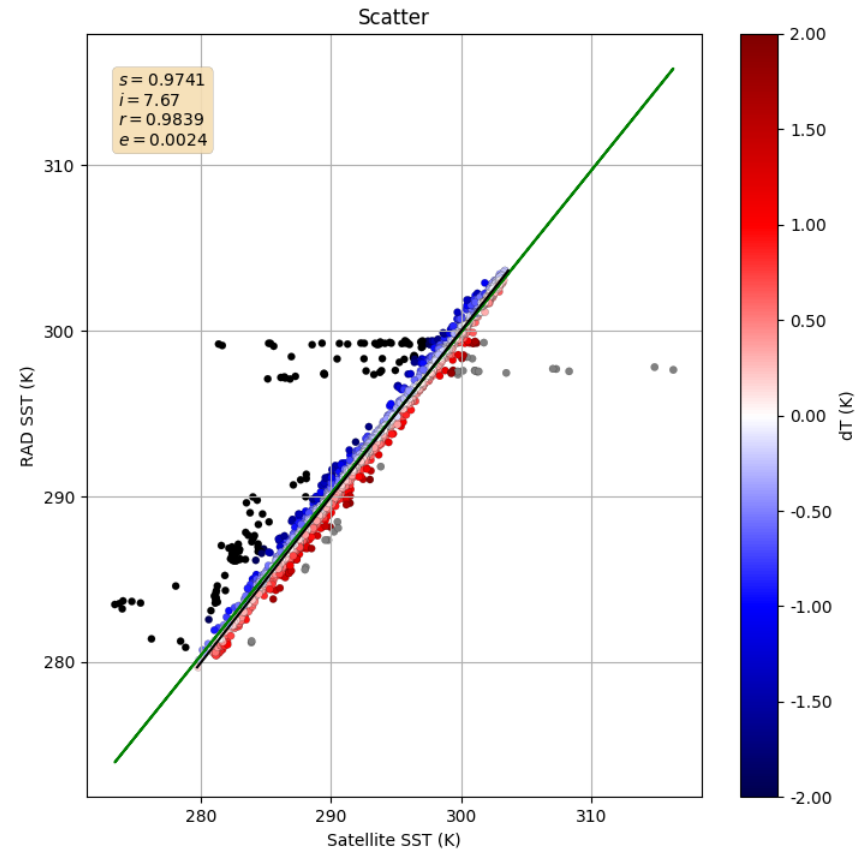
s4sstr1i1, all, sstdiff_sst_wst, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20200508 (c) 2020 ISAR team - v5.2

Validation scatter – all

NRT: 2018



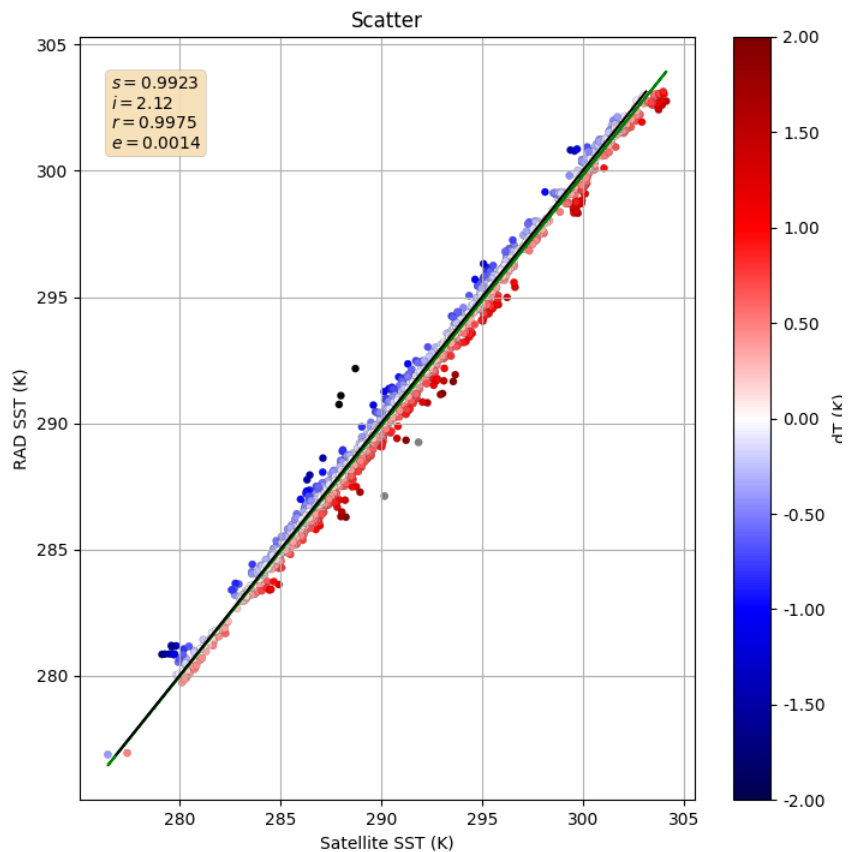
s4sstr111, all, sstdiff_sst_wst, grade 2b, day, ghrsst-all, qi-all - HuberT processed 20200508 (c) 2020 ISAR team - v5.2



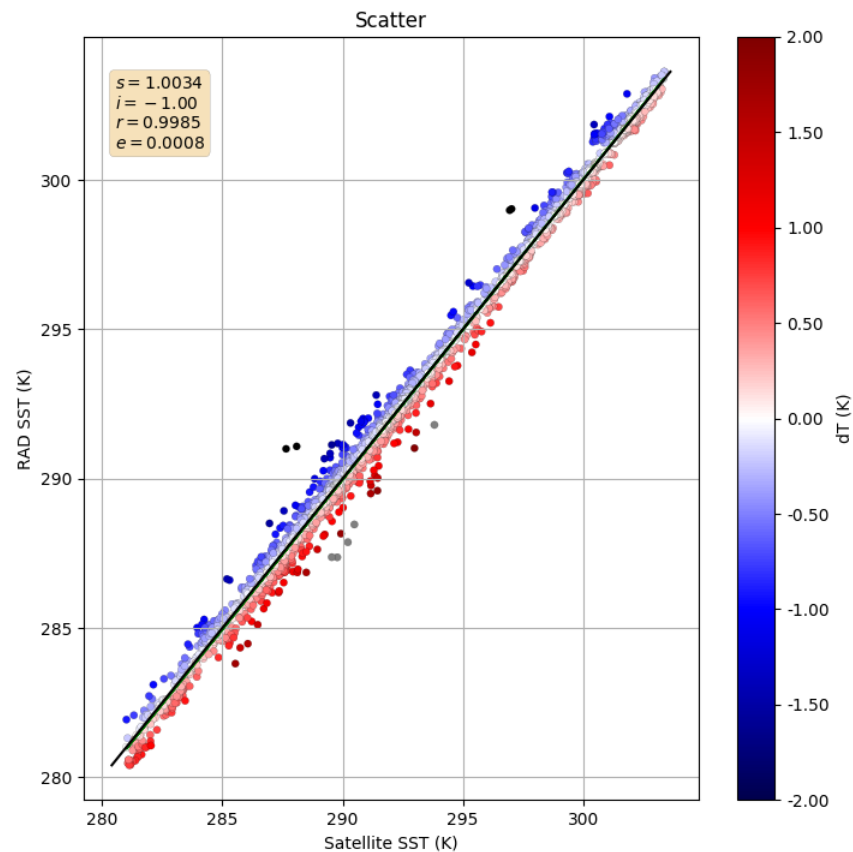
s4sstr111, all, sstdiff_sst_wst, grade 2b, night, ghrsst-all, qi-all - HuberTprocessed 20200508 (c) 2020 ISAR team - v5.2

Validation – scatter, CV 5

NRT: 2018



s4sstr1i1, all, sstdiff_sst_wst, grade 2b, day, ghrsst-5, qi-all - HuberT processed 20200508 (c) 2020 ISAR team - v5.1



s4sstr1i1, all, sstdiff_sst_wst, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20200508 (c) 2020 ISAR team - v5.2

Validation results – statistics

- NRT: 2018

Day						
Grade	MDiff	RSD	No	Overpass	Min Temp	Max Temp
1	0.09	0.29	1040	117	279.51	304.03
2a	0.04	0.43	3202	224	270.45	305.87
2b	0.12	0.37	3965	187	271.88	312.34
3	0.05	0.49	12219	295	270.18	313.67
4	0.02	0.60	33461	384	270.18	317.94

WST						
ALL						
Grade	MDiff	RSD	No	Overpass	Min Temp	Max Temp
1	0.08	0.26	2457	269	279.51	304.03
2a	0.03	0.37	6975	490	270.45	305.87
2b	0.06	0.30	9294	416	271.88	316.34
3	0.02	0.40	26753	609	270.18	316.34
4	-0.01	0.47	71568	754	270.18	317.94

Night						
Grade	MDiff	RSD	No	Overpass	Min Temp	Max Temp
1	0.06	0.24	1417	152	279.77	303.23
2a	0.03	0.33	3773	266	270.82	303.47
2b	0.02	0.26	5329	229	273.35	316.34
3	-0.01	0.34	14534	315	270.60	316.34
4	-0.03	0.38	38107	376	270.54	317.94

Validation results – statistics

- NRT: 2018 – CV 5

Day						
Grade	MDiff	RSD	No	Overpass	Min Temp	Max Temp
1	0.09	0.21	649	74	279.51	304.03
2a	0.11	0.30	1844	144	274.94	305.13
2b	0.13	0.27	2433	138	276.46	304.14
3	0.11	0.36	7018	205	274.94	305.13
4	0.09	0.46	18957	287	274.70	305.37

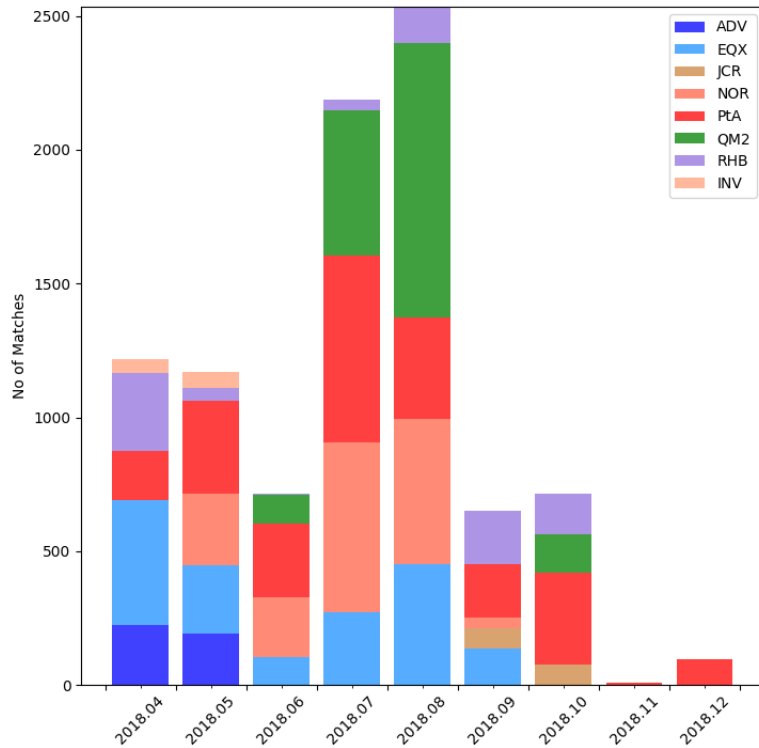
WST						
ALL						
Grade	MDiff	RSD	No	Overpass	Min Temp	Max Temp
1	0.07	0.21	1827	205	279.51	304.03
2a	0.06	0.29	4984	374	274.94	305.13
2b	0.06	0.24	6895	339	276.46	304.14
3	0.04	0.32	19049	481	273.56	305.13
4	0.02	0.38	50565	624	273.56	305.57

Night						
Grade	MDiff	RSD	No	Overpass	Min Temp	Max Temp
1	0.06	0.21	1178	131	281.07	303.23
2a	0.03	0.29	3140	230	276.67	303.47
2b	0.03	0.23	4462	201	281.01	303.39
3	0.00	0.30	12031	276	273.56	303.50
4	-0.02	0.33	31608	337	273.56	305.57

Validation results – RDAC split

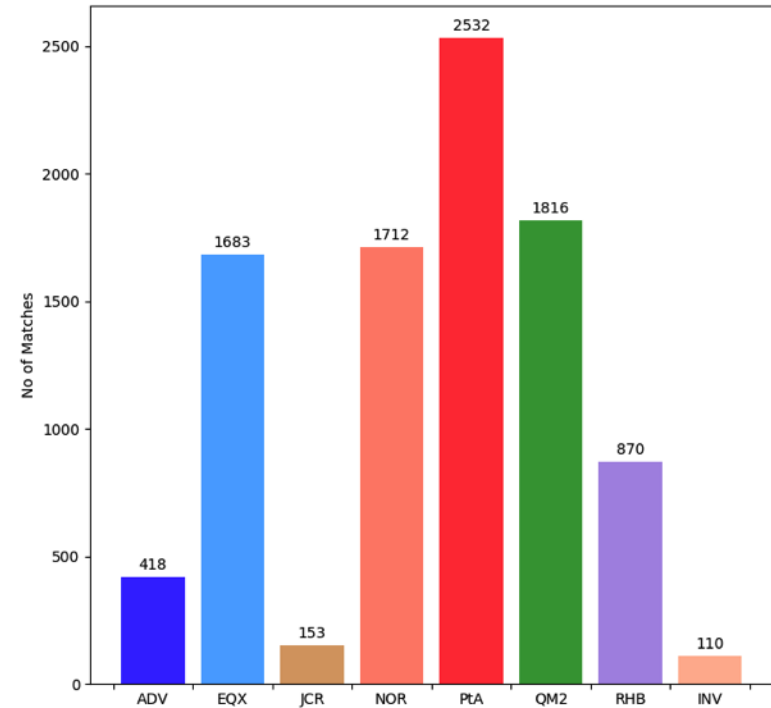
- NRT: 2018

Abbreviation	Ships name	Operator
ADV	MV Adventure of the Seas	RSMAS
ALE	MV Allure of the Seas	RSMAS
DCY	RRS Discovery	UoS
EQX	MV Celebrity Equinox	RSMAS
JCR	RRS James Clark Ross	UoS
NOR	M/V Norrana	DMI
PtA	MV Pont Aven	UoS
QM2	MV Queen Mary 2	RAL
MaU	RV Minerva Uno	RSMAS
RHB	RV Ronald H. Brown	RSMAS
INV	RV Investigator	CSIRO



all, sstdiff_sst_wst, grade 2b, all, ghrsst-all - HuberT

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all, sstdiff_sst_wst, grade 2b, all, ghrsst-all - HuberT

processed 20200403 (c) 2020 ISAR team - v4.1