



# ships4sst

shipborne radiometers for sea surface temperature

## Using ships4sst data to validate SLSTR data

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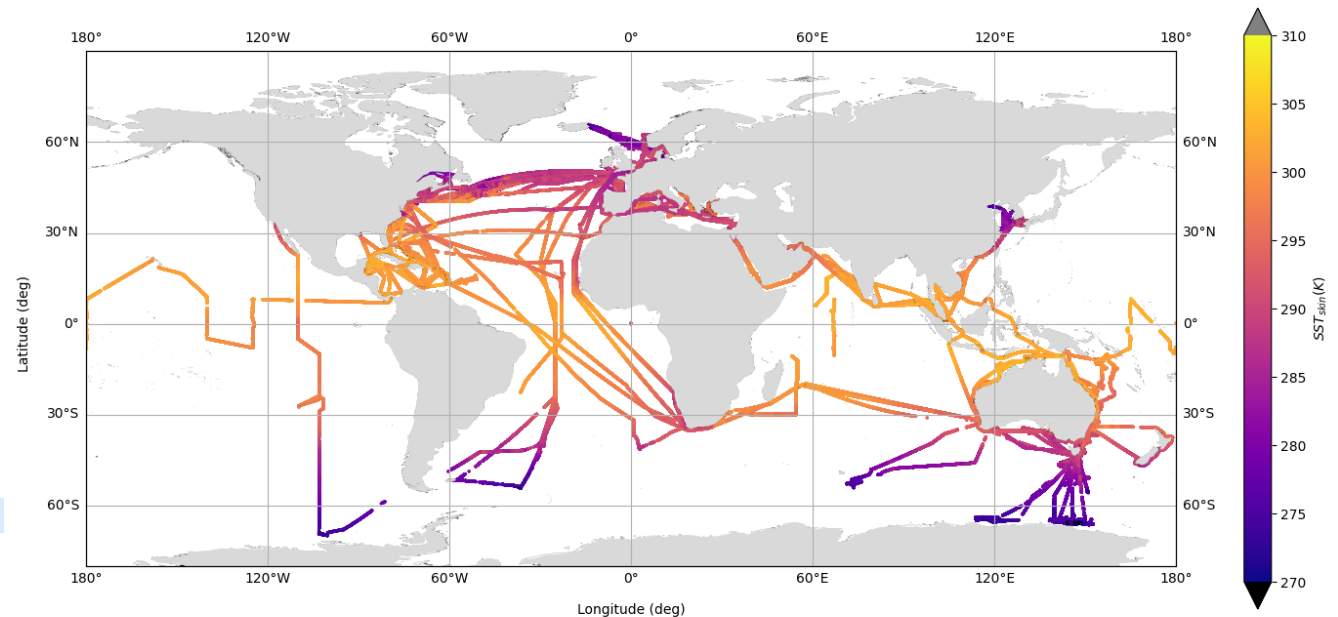
With contributions from: A. Lee, G. Dybkjær, R. Holmes, J.F. Piolle, I. Tomazic

# Outline

- Introduction
  - Data sources
  - Validation methods
- Validation Results
  - NRT 2019 – global
  - QI results – 2019 – global
  - D3, D2, N3, N2 results for the 2019 data (Jan to Jun) – global
- Conclusion

# Data

- SLSTR
  - NRT data 2019
- 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

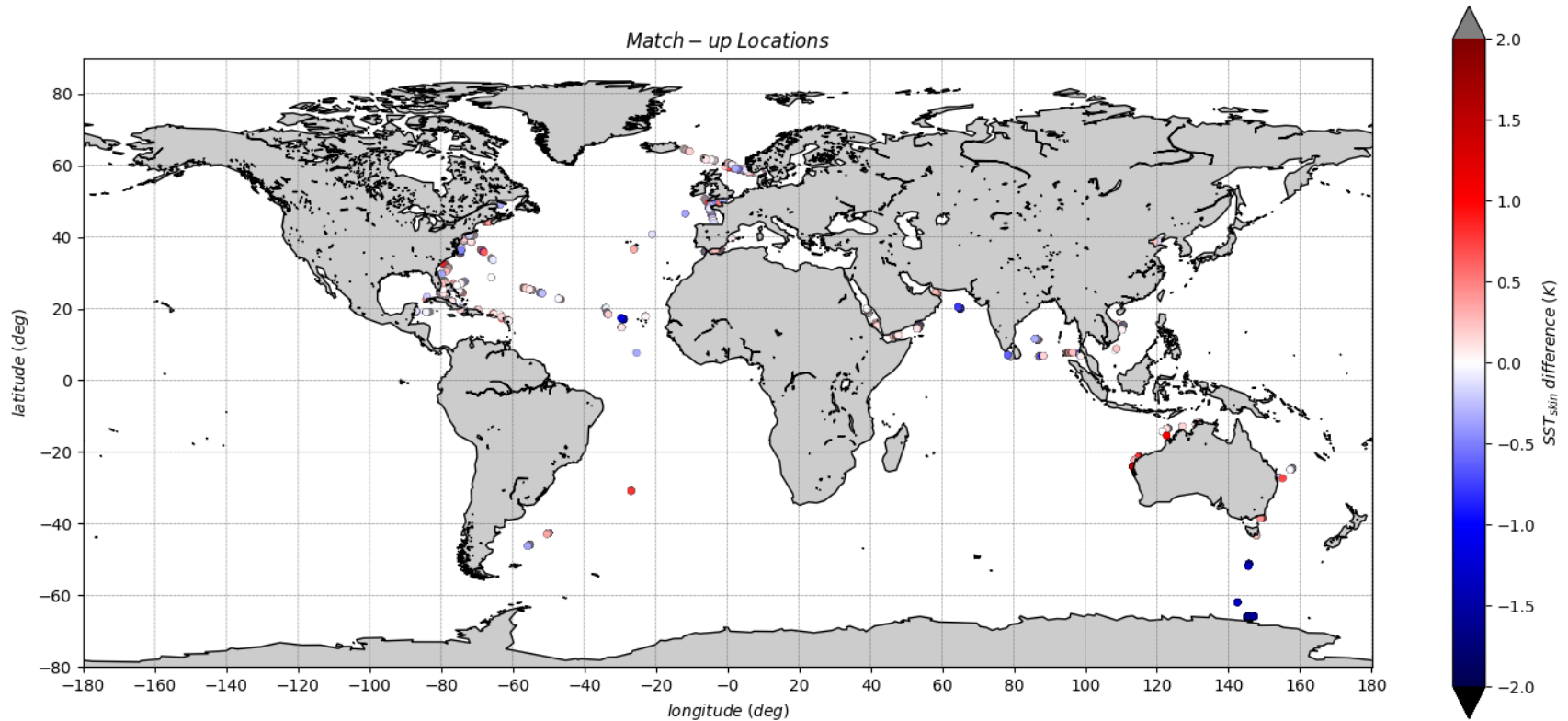
# Validation methods

- 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

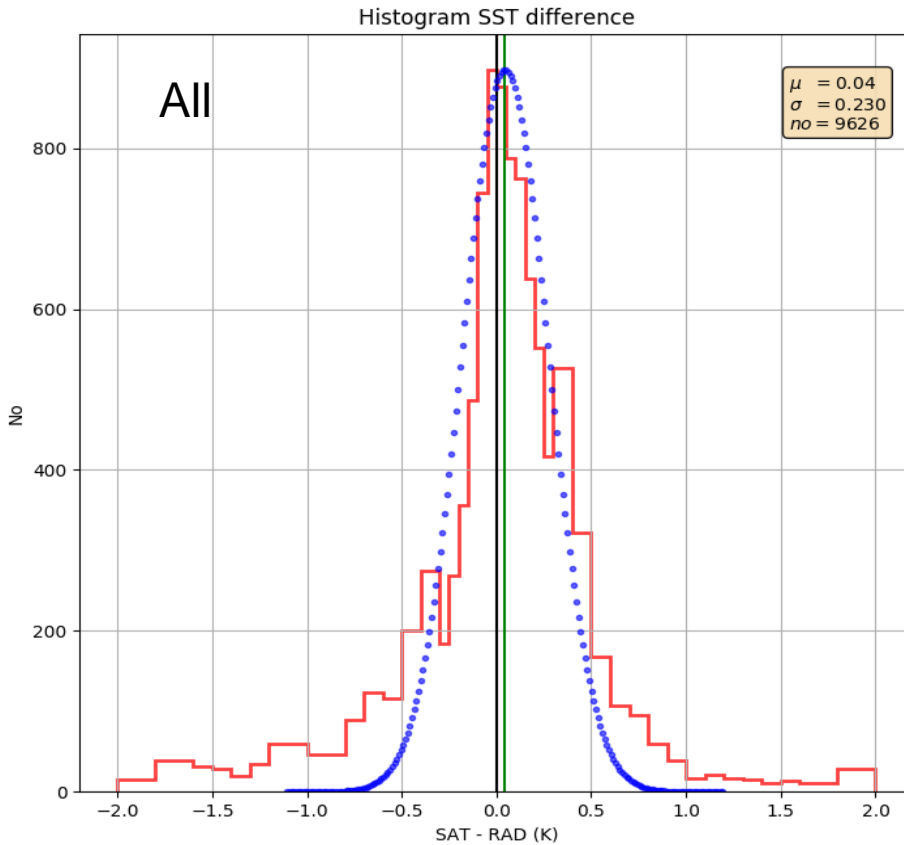
# Validation results - global

- WST - 2019, CV5, grade 2b - S3A

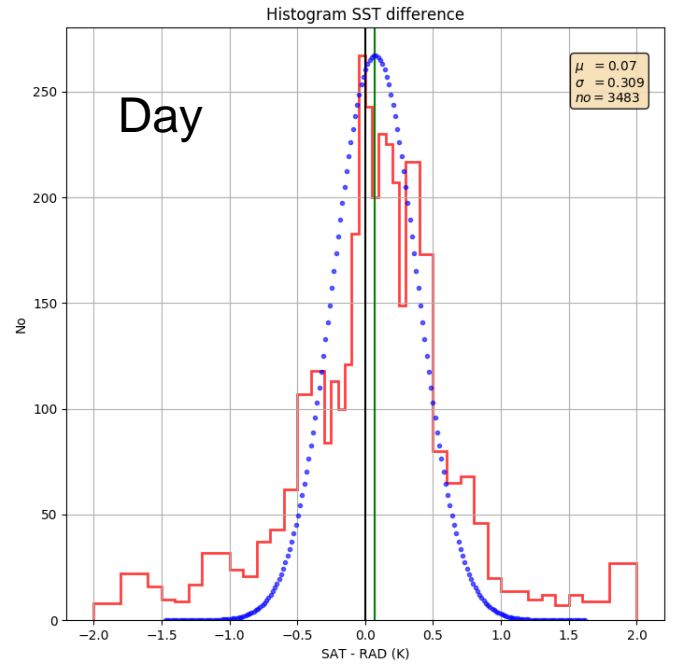


# Validation results – histograms - all

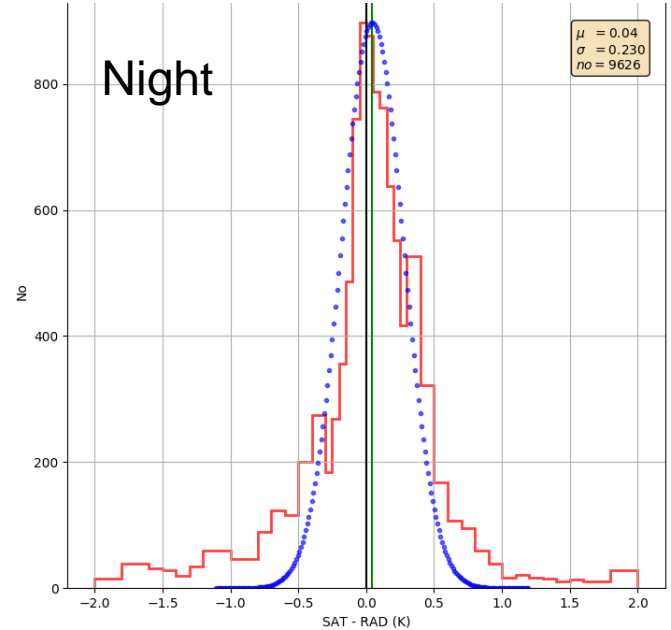
2019 - S3A



s4sstr1i1, all, sstdiff\_sst\_wst, grade 2b, all, ghrsst-all, qi-all - HuberT processed 20210604 (c) 2021 ISAR team - v5.3



s4sstr1i1, all, sstdiff\_sst\_wst, grade 2b, day, ghrsst-all, qi-all - HuberT processed 20210604 (c) 2021 ISAR team - v5.3



s4sstr1i1, all, sstdiff\_sst\_wst, grade 2b, all, ghrsst-all, qi-all - HuberT processed 20210604 (c) 2021 ISAR team - v5.3

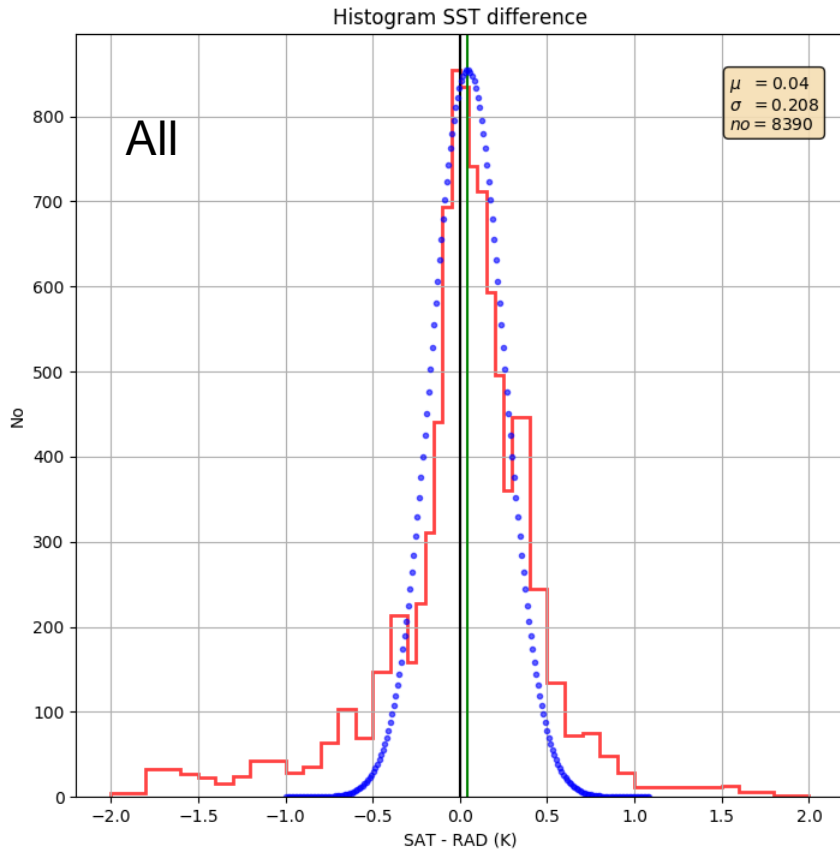
ships4sst: FRM4SST

FRM4SST: ISRN workshop validation

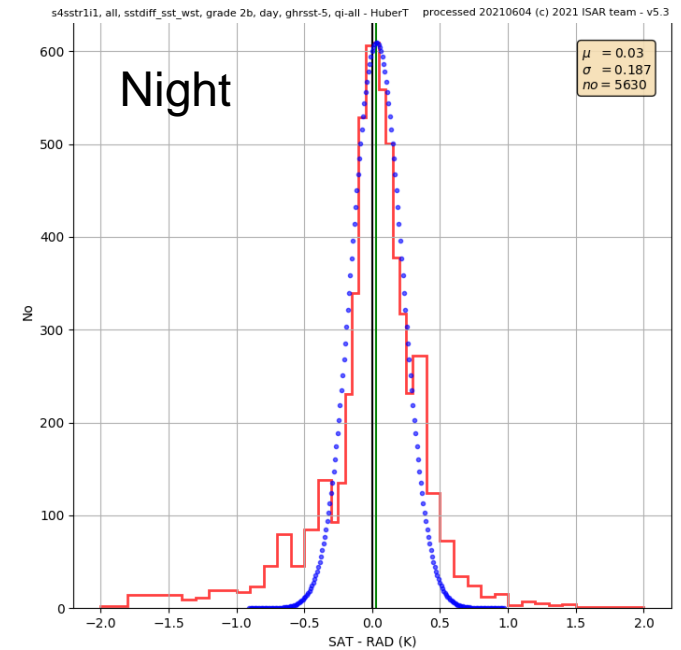
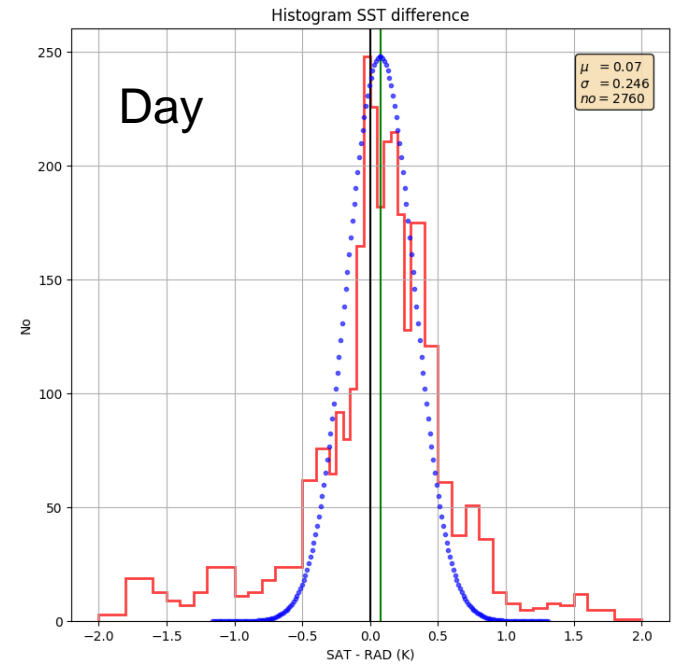


# Histograms – CV5

2010-2018



s4sstr1i1, all, sstdiff\_sst\_wst, grade 2b, all, ghrsst-5, qi-all - HuberT processed 20210604 (c) 2021 ISAR team - v5.3



s4sstr1i1, all, sstdiff\_sst\_wst, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20210604 (c) 2021 ISAR team - v5.3

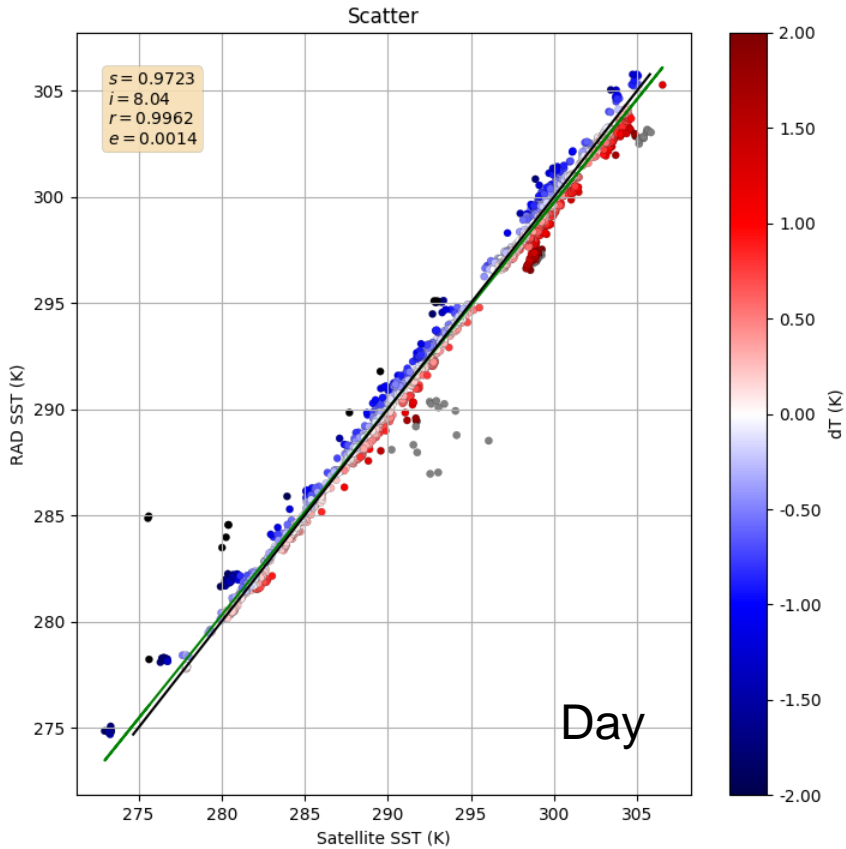
ships4sst: FRM4SST

FRM4SST: ISRN workshop validation

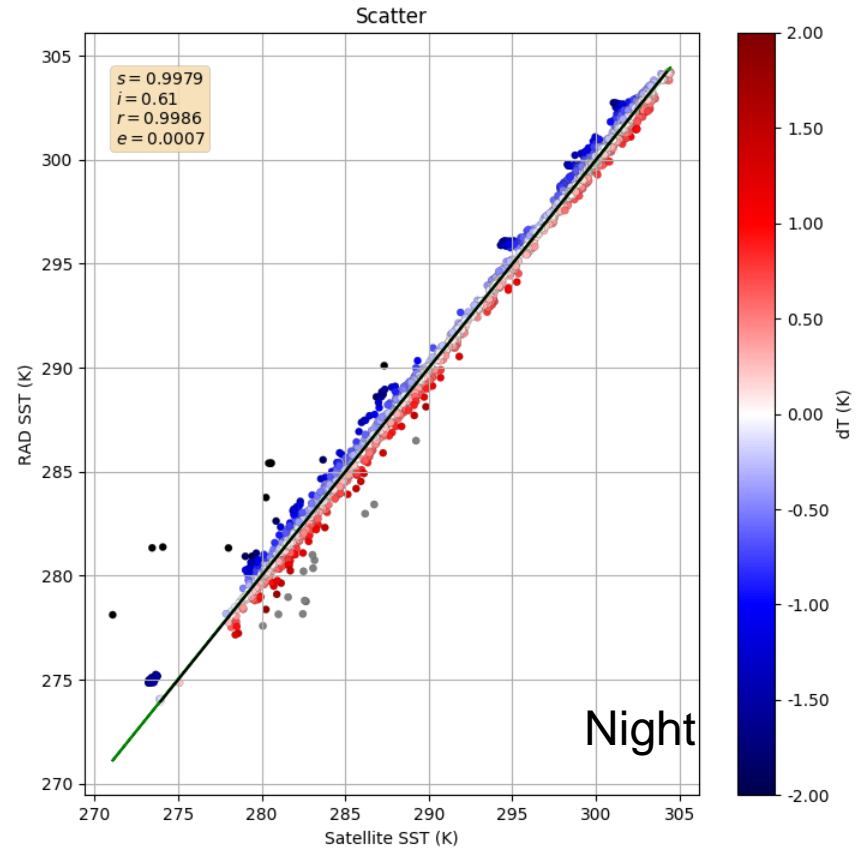


# Validation scatter – all

2019 - S3A



s4sstr111, all, sstdiff\_sst\_wst, grade 2b, day, ghrsst-all, qi-all - HuberT processed 20210604 (c) 2021 ISAR team - v5.3

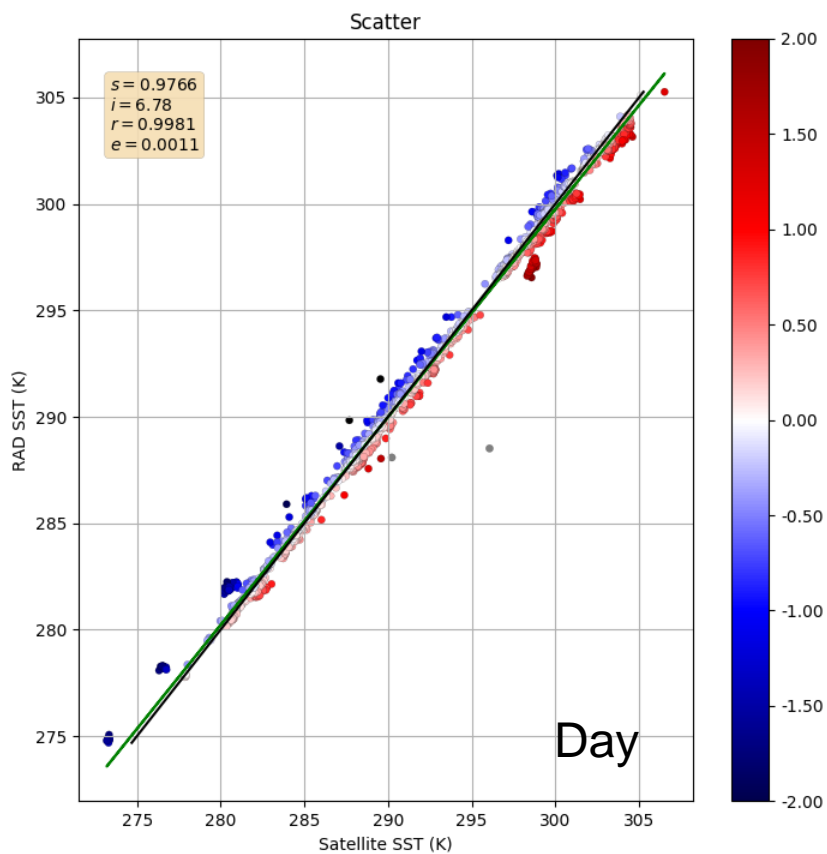


s4sstr111, all, sstdiff\_sst\_wst, grade 2b, night, ghrsst-all, qi-all - HuberTprocessed 20210604 (c) 2021 ISAR team - v5.3

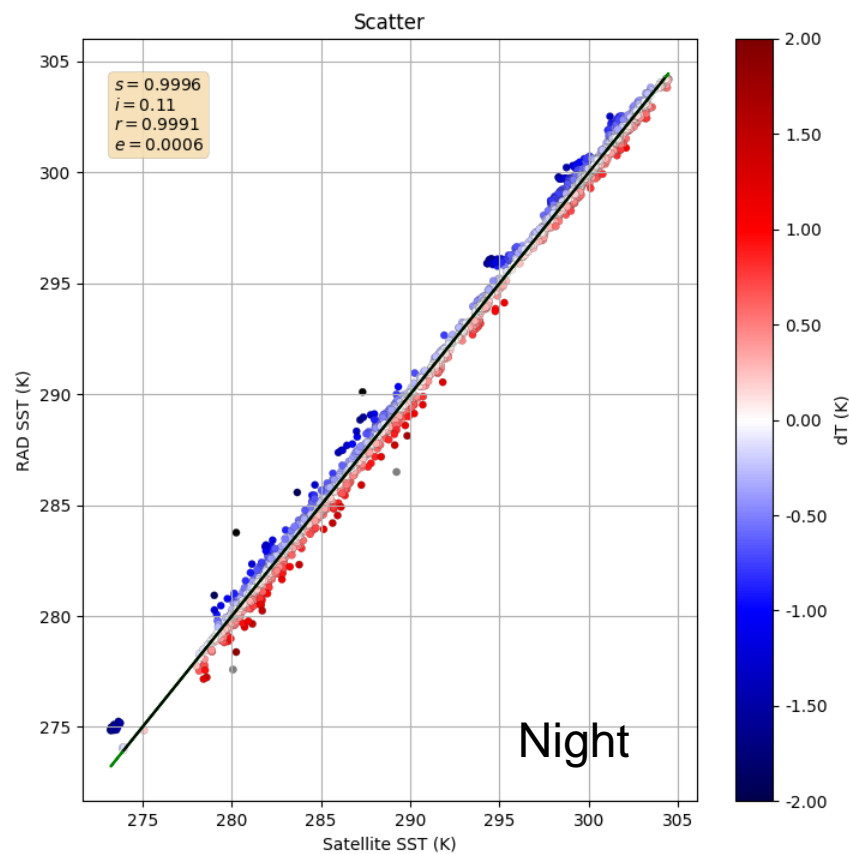


# Validation – scatter, CV 5

2019 - S3A



s4sstr111, all, sstdiff\_sst\_wst, grade 2b, day, ghrsst-5, qi-all - HuberT processed 20210604 (c) 2021 ISAR team - v5.3



s4sstr111, all, sstdiff\_sst\_wst, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20210604 (c) 2021 ISAR team - v5.3

# Validation results – statistics

- 2019 - S3A: All data

Day						
Grade	MDif f	RSD	No	Overpass	Min Temp	Max Tem
1	0.07	0.26	832	100	275.57	306.53
2a	0.04	0.44	3346	209	270.61	306.53
<b>2b</b>	<b>0.07</b>	<b>0.31</b>	<b>3483</b>	<b>162</b>	<b>272.97</b>	<b>306.53</b>
3	0.02	0.47	12915	266	270.16	307.54
4	0.01	0.51	38087	375	270.15	316.10

WST						
ALL						
Grade	MDif f	RSD	No	Overpass	Min Temp	Max Tem
1	0.03	0.21	2462	273	273.22	306.53
2a	0.02	0.31	8035	504	270.61	306.53
<b>2b</b>	<b>0.04</b>	<b>0.23</b>	<b>9626</b>	<b>413</b>	<b>271.08</b>	<b>306.53</b>
3	0.02	0.34	31130	621	270.16	307.54
4	-0.01	0.38	87601	813	270.15	316.10

Night						
Grade	MDif f	RSD	No	Overpass	Min Temp	Max Tem
1	0.01	0.19	1630	173	273.22	303.28
2a	0.02	0.25	4689	296	270.90	305.80
<b>2b</b>	<b>0.03</b>	<b>0.20</b>	<b>6143</b>	<b>253</b>	<b>271.08</b>	<b>304.47</b>
3	0.02	0.27	18215	357	270.51	305.80
4	-0.01	0.31	49514	441	270.20	305.80

# Validation results – statistics

- 2019 - S3A: CV5

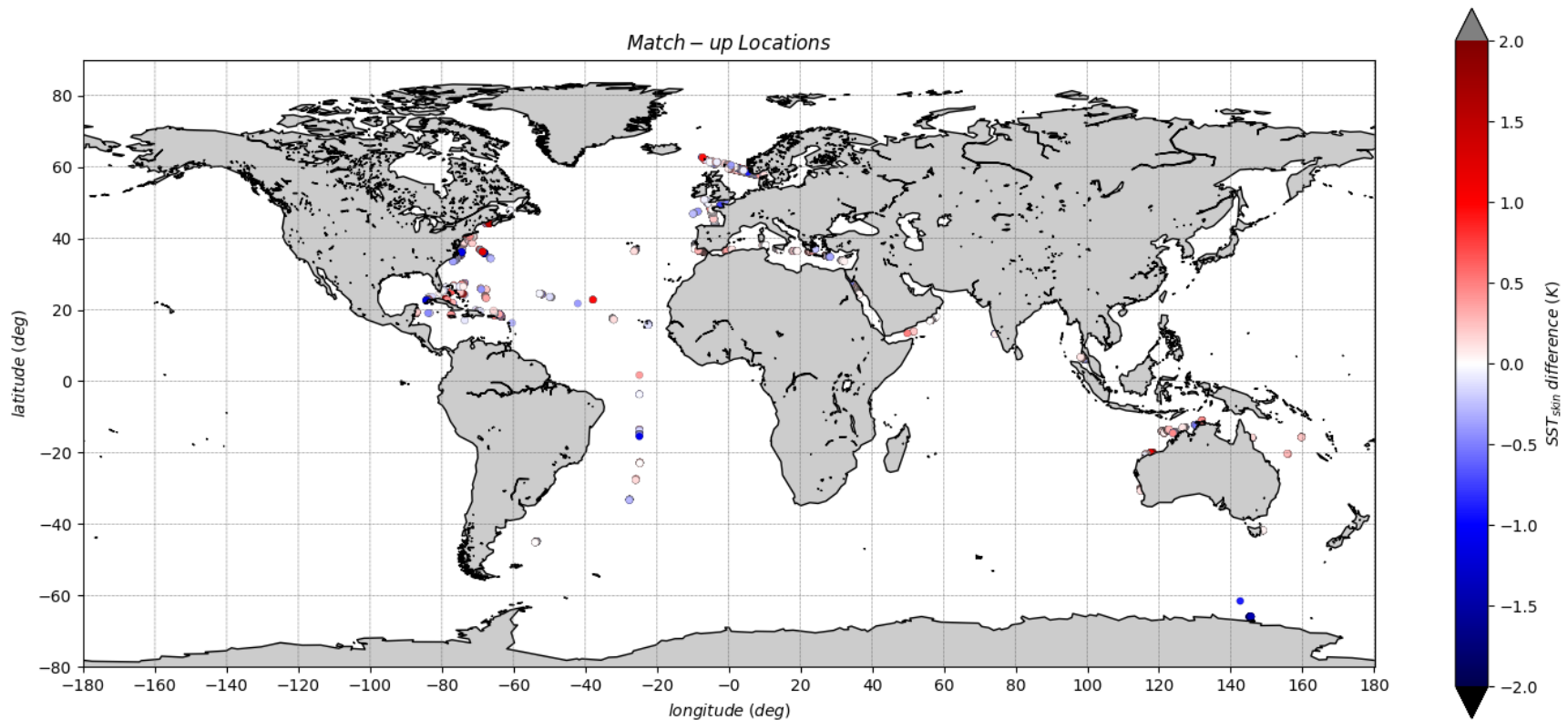
Day						
Grade	MDiff	RSD	No	Overpass	Min Temp	Max Tem
1	0.08	0.22	660	80	276.32	306.53
2a	0.08	0.35	2352	158	273.22	306.53
<b>2b</b>	<b>0.07</b>	<b>0.25</b>	<b>2760</b>	<b>133</b>	<b>273.19</b>	<b>306.53</b>
3	0.06	0.37	8924	206	273.19	306.53
4	0.06	0.41	25865	299	273.15	307.07

WST						
ALL						
Grade	MDiff	RSD	No	Overpass	Min Temp	Max Tem
1	0.03	0.19	2151	238	273.22	306.53
2a	0.04	0.26	6504	429	273.18	306.53
<b>2b</b>	<b>0.04</b>	<b>0.21</b>	<b>8390</b>	<b>362</b>	<b>273.19</b>	<b>306.53</b>
3	0.04	0.29	24993	538	273.15	306.53
4	0.02	0.33	69587	711	273.15	307.07

Night						
Grade	MDiff	RSD	No	Overpass	Min Temp	Max Tem
1	0.01	0.17	1491	158	273.22	303.20
2a	0.03	0.23	4152	271	273.18	305.80
<b>2b</b>	<b>0.03</b>	<b>0.19</b>	<b>5630</b>	<b>229</b>	<b>273.22</b>	<b>304.47</b>
3	0.03	0.25	16069	332	273.15	305.80
4	0.00	0.29	43722	412	273.15	305.80

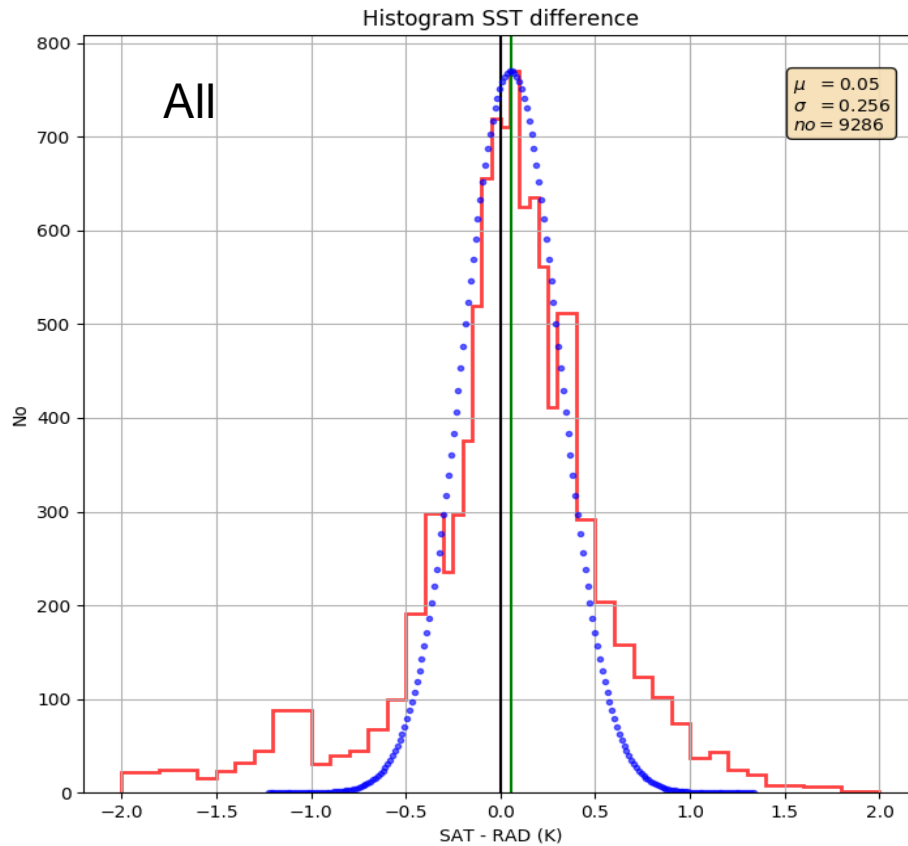
# Validation results - global

- WST - 2019, CV5, grade 2b - S3B

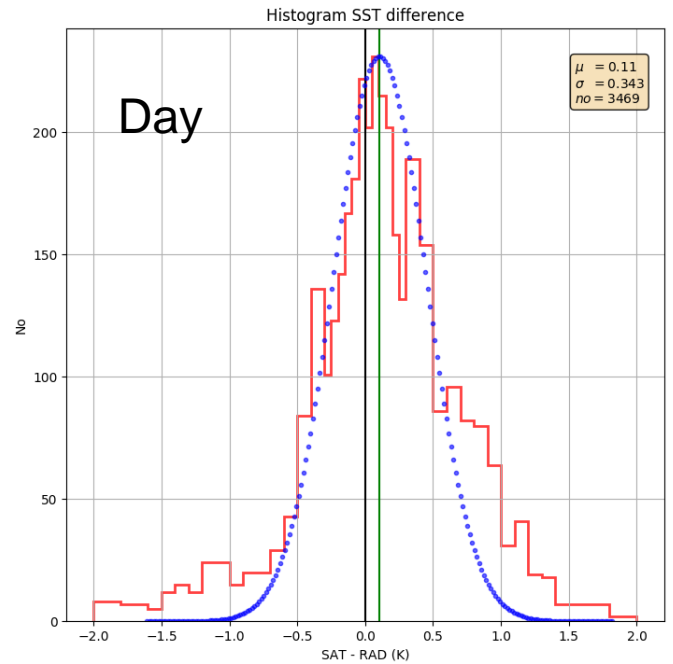


# Validation results – histograms - all

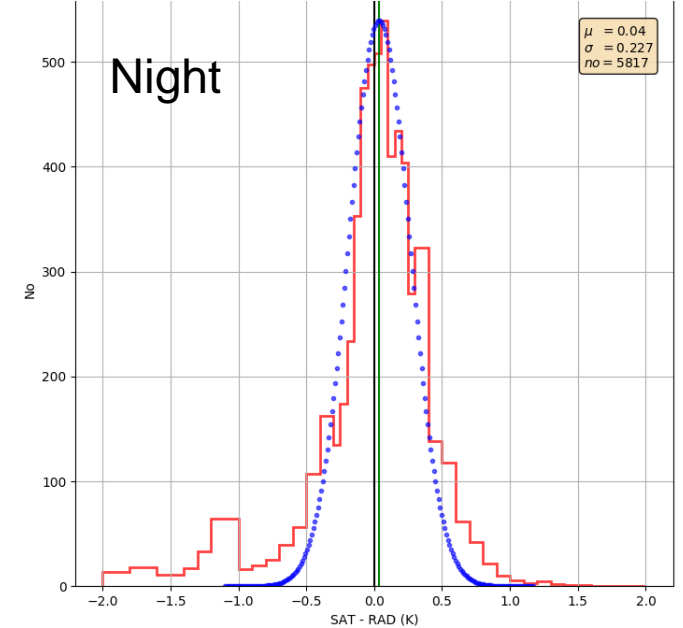
2019 - S3B



s4sstr1i1, all, sstdiff\_sst\_wst, grade 2b, all, ghrsst-all, qi-all - HuberT processed 20210604 (c) 2021 ISAR team - v5.3



s4sstr1i1, all, sstdiff\_sst\_wst, grade 2b, day, ghrsst-all, qi-all - HuberT processed 20210604 (c) 2021 ISAR team - v5.3



s4sstr1i1, all, sstdiff\_sst\_wst, grade 2b, night, ghrsst-all, qi-all - HuberT processed 20210604 (c) 2021 ISAR team - v5.3

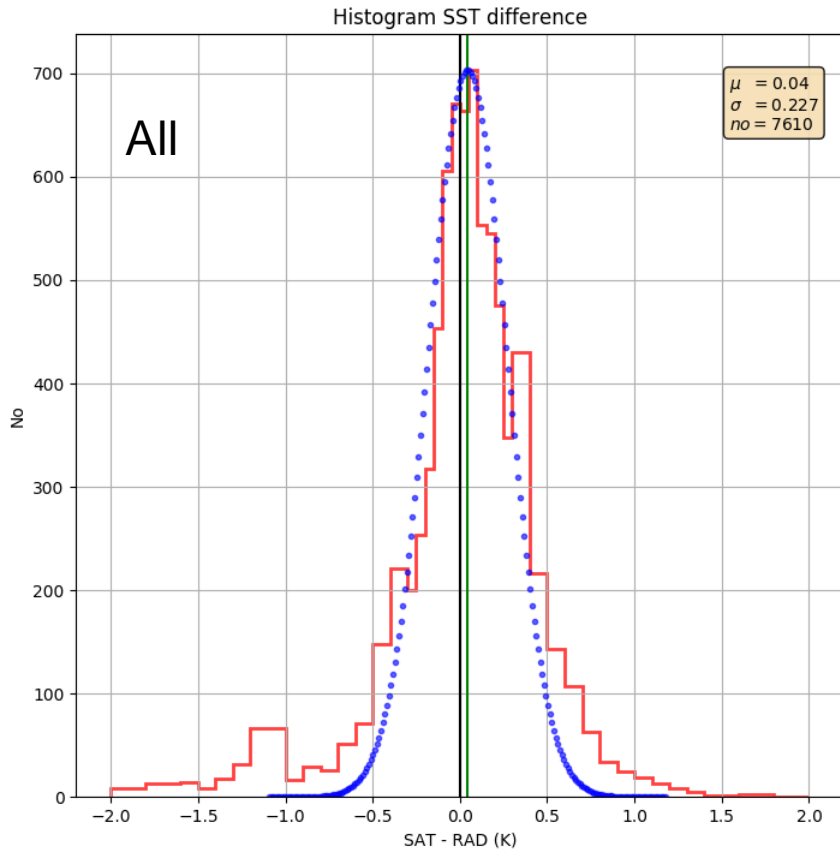
ships4sst: FRM4SST

FRM4SST: ISFRN workshop – validation



# Histograms – CV5

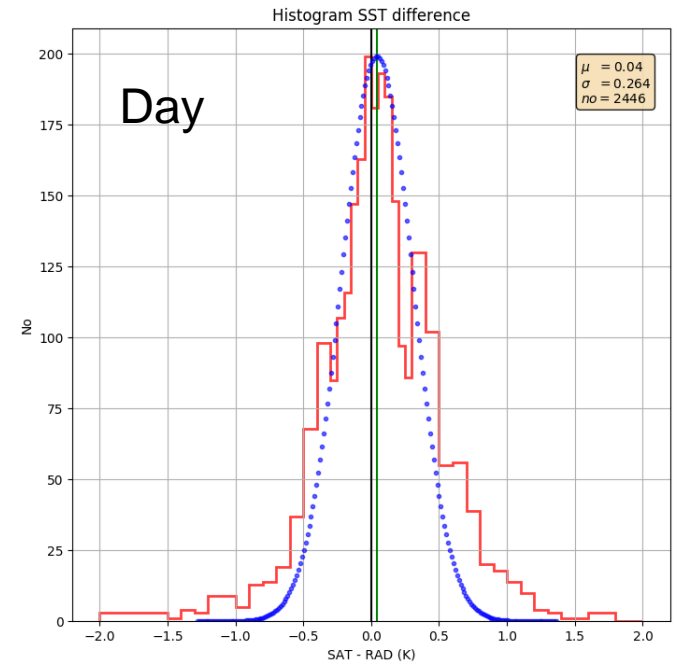
2019 - S3B



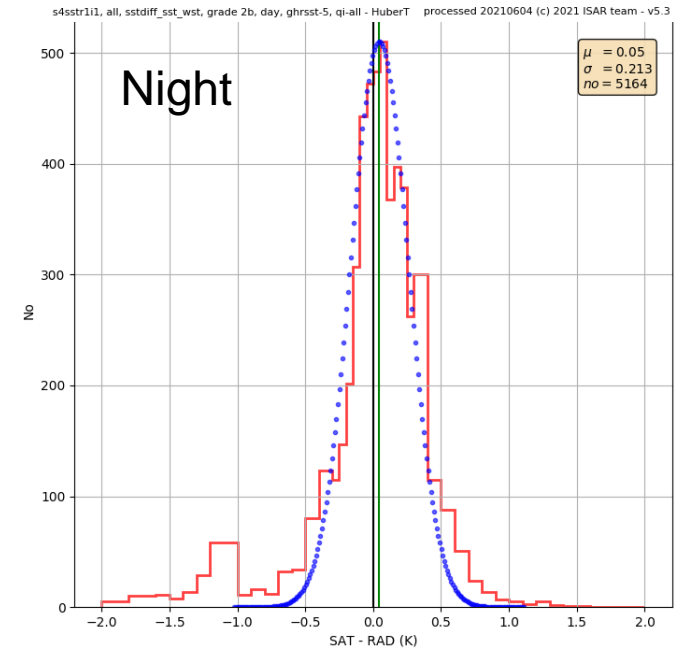
s4sstr1i1, all, sstdiff\_sst\_wst, grade 2b, all, ghrsst-5, qi-all - HuberT processed 20210604 (c) 2021 ISAR team - v5.3

ships4sst: FRM4SST

FRM4SST: ISFRN workshop – validation



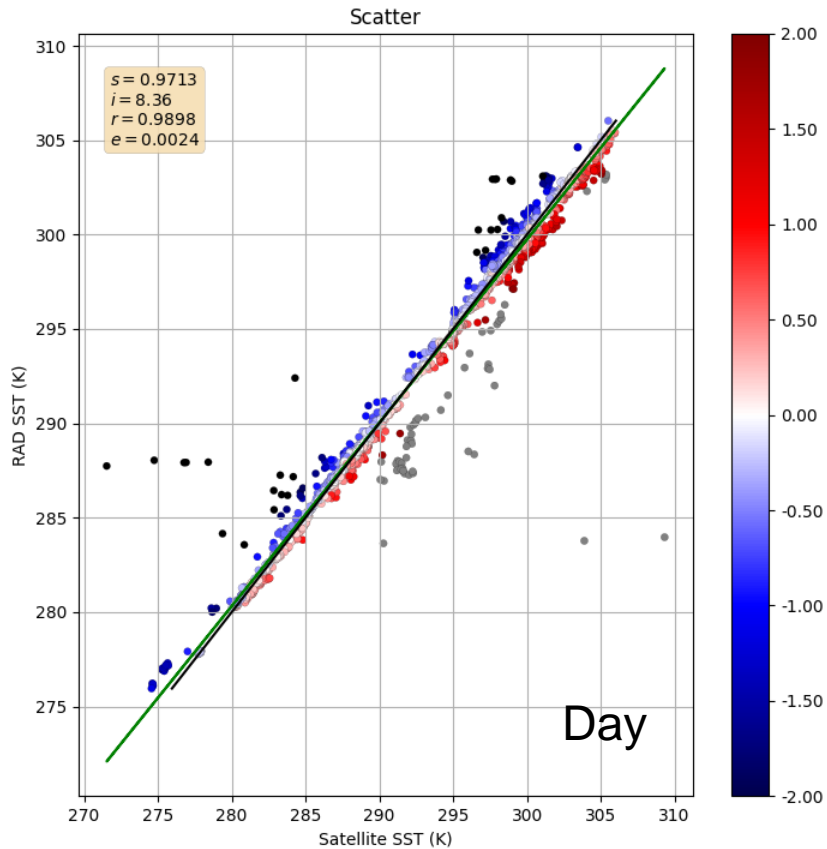
s4sstr1i1, all, sstdiff\_sst\_wst, grade 2b, day, ghrsst-5, qi-all - HuberT processed 20210604 (c) 2021 ISAR team - v5.3



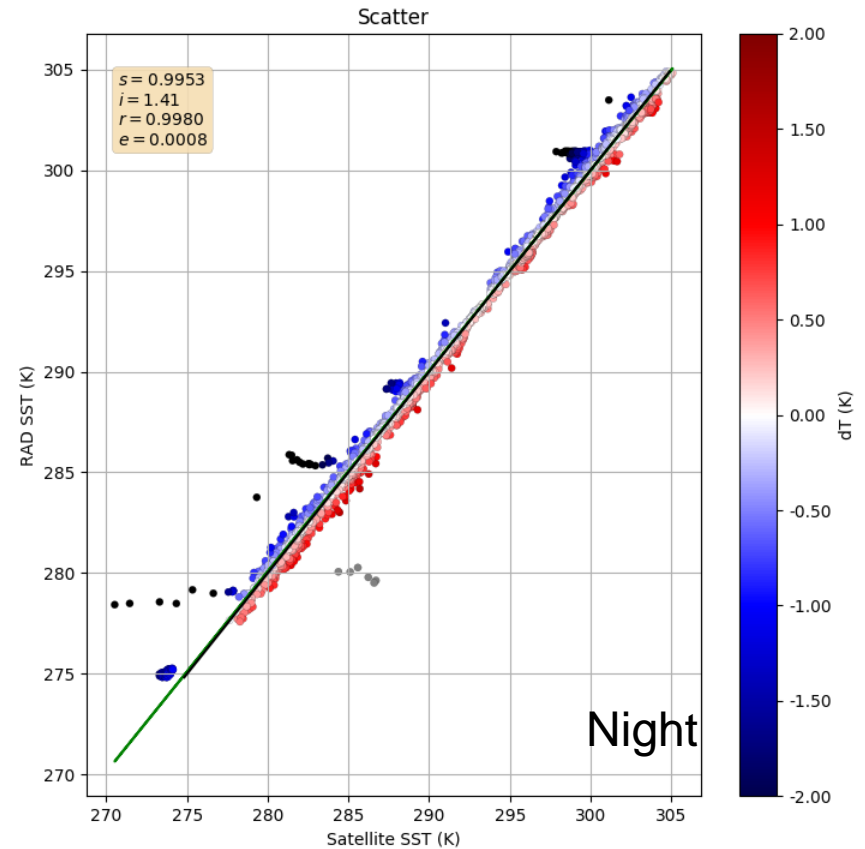
s4sstr1i1, all, sstdiff\_sst\_wst, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20210604 (c) 2021 ISAR team - v5.3

# Validation scatter – all

2019 - S3B



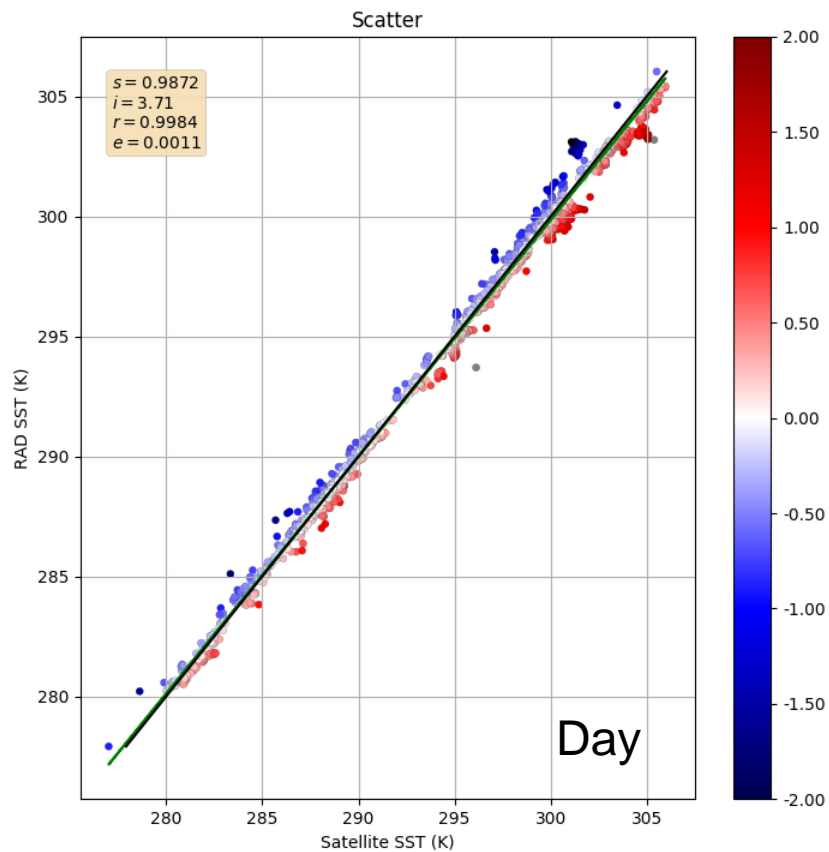
s4sstr11, all, sstdiff\_sst\_wst, grade 2b, day, ghrsst-all, qi-all - HuberT processed 20210604 (c) 2021 ISAR team - v5.3



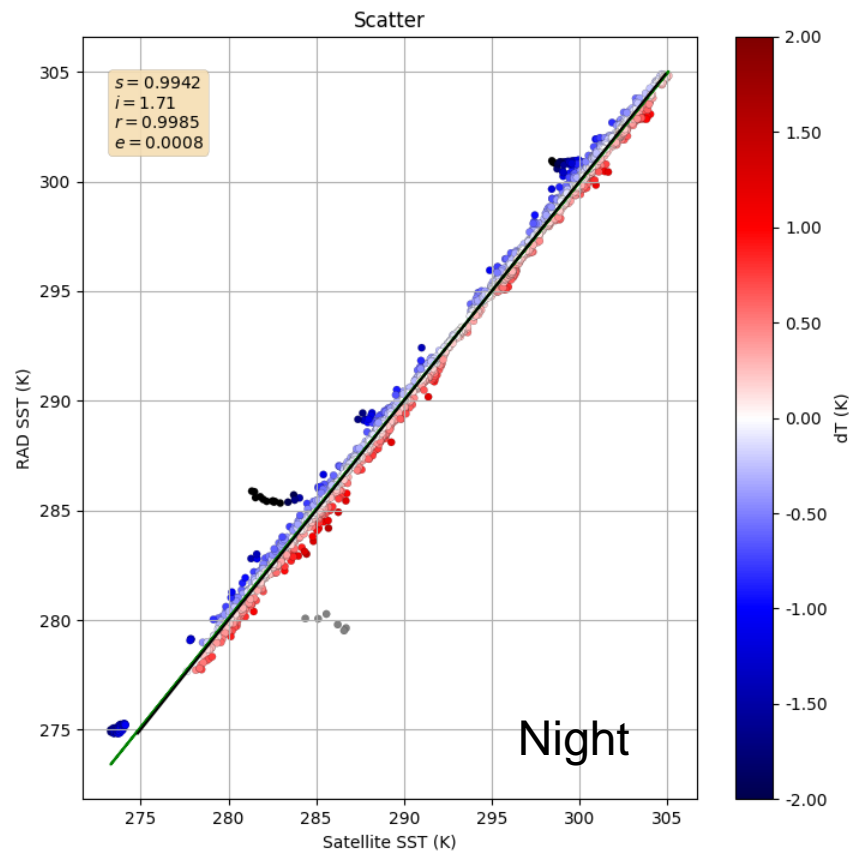
s4sstr11, all, sstdiff\_sst\_wst, grade 2b, night, ghrsst-all, qi-all - HuberTprocessed 20210604 (c) 2021 ISAR team - v5.3

# Validation – scatter, CV 5

2019 - S3A



s4sstr111, all, sstdiff\_sst\_wst, grade 2b, day, ghrsst-5, qi-all - HuberT processed 20210604 (c) 2021 ISAR team - v5.3



s4sstr111, all, sstdiff\_sst\_wst, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20210604 (c) 2021 ISAR team - v5.3



# Validation results – statistics

- 2019 - S3B: All data

Day						
Grade	MDif f	RSD	No	Overpass	Min Temp	Max Tem
1	0.10	0.29	825	93	280.28	305.16
2 a	0.02	0.40	3282	201	271.12	306.53
<b>2 b</b>	<b>0.11</b>	<b>0.34</b>	<b>3469</b>	<b>160</b>	<b>271.53</b>	<b>309.33</b>
3	0.02	0.44	12792	266	270.25	317.49
4	0.01	0.48	38832	372	270.21	317.81

WST						
ALL						
Grade	MDif f	RSD	No	Overpass	Min Temp	Max Tem
1	0.06	0.23	2289	247	273.75	305.16
2 a	0.02	0.32	8008	491	271.12	306.53
<b>2 b</b>	<b>0.05</b>	<b>0.26</b>	<b>9286</b>	<b>393</b>	<b>270.52</b>	<b>309.33</b>
3	0.02	0.34	31177	620	270.25	317.49
4	0.01	0.38	88442	788	270.21	317.81

Night						
Grade	MDif f	RSD	No	Overpass	Min Temp	Max Tem
1	0.04	0.21	1464	154	273.75	305.08
2 a	0.01	0.29	4726	290	272.35	305.88
<b>2 b</b>	<b>0.04</b>	<b>0.23</b>	<b>5817</b>	<b>233</b>	<b>270.52</b>	<b>305.08</b>
3	0.02	0.29	18385	354	270.52	306.05
4	0.01	0.32	49610	418	270.38	306.98

# Validation results – statistics

- 2019 - S3B: CV5

Day						
Grade	MDif f	RSD	No	Overpass	Min Temp	Max Tem
1	0.05	0.22	597	76	280.32	305.16
2a	0.08	0.29	2181	150	273.15	306.23
<b>2b</b>	<b>0.04</b>	<b>0.26</b>	<b>2446</b>	<b>123</b>	<b>277.01</b>	<b>305.97</b>
3	0.05	0.33	8595	210	273.15	306.81
4	0.03	0.37	26331	300	273.15	308.01

WST						
ALL						
Grade	MDif f	RSD	No	Overpass	Min Temp	Max Tem
1	0.05	0.20	1894	217	273.75	305.16
2a	0.05	0.27	6088	408	273.15	306.23
<b>2b</b>	<b>0.04</b>	<b>0.23</b>	<b>7610</b>	<b>338</b>	<b>273.29</b>	<b>305.97</b>
3	0.04	0.29	23892	531	273.15	306.81
4	0.03	0.32	68598	691	273.15	308.01

Night						
Grade	MDif f	RSD	No	Overpass	Min Temp	Max Tem
1	0.05	0.19	1297	141	273.75	305.08
2a	0.03	0.26	3907	258	273.25	305.88
<b>2b</b>	<b>0.05</b>	<b>0.21</b>	<b>5164</b>	<b>215</b>	<b>273.29</b>	<b>305.08</b>
3	0.04	0.27	15297	321	273.17	306.05
4	0.03	0.29	42267	391	273.15	306.05

# Validation results – statistics

## 2019 – S3 A vs B

Day						
Grade	MDif f	RSD	No	Overpass	Min Temp	Max Tem
1	0.05	0.22	597	76	280.32	305.16
2a	0.08	0.29	2181	150	273.15	306.23
<b>2b</b>	<b>0.04</b>	<b>0.26</b>	<b>2446</b>	<b>123</b>	<b>277.01</b>	<b>305.97</b>
3	0.05	0.33	8595	210	273.15	306.81
4	0.03	0.37	26331	300	273.15	308.01

Day						
Grade	MDif f	RSD	No	Overpass	Min Temp	Max Tem
1	0.08	0.22	660	80	276.32	306.53
2a	0.08	0.35	2352	158	273.22	306.53
<b>2b</b>	<b>0.07</b>	<b>0.25</b>	<b>2760</b>	<b>133</b>	<b>273.19</b>	<b>306.53</b>
3	0.06	0.37	8924	206	273.19	306.53
4	0.06	0.41	25865	299	273.15	307.07

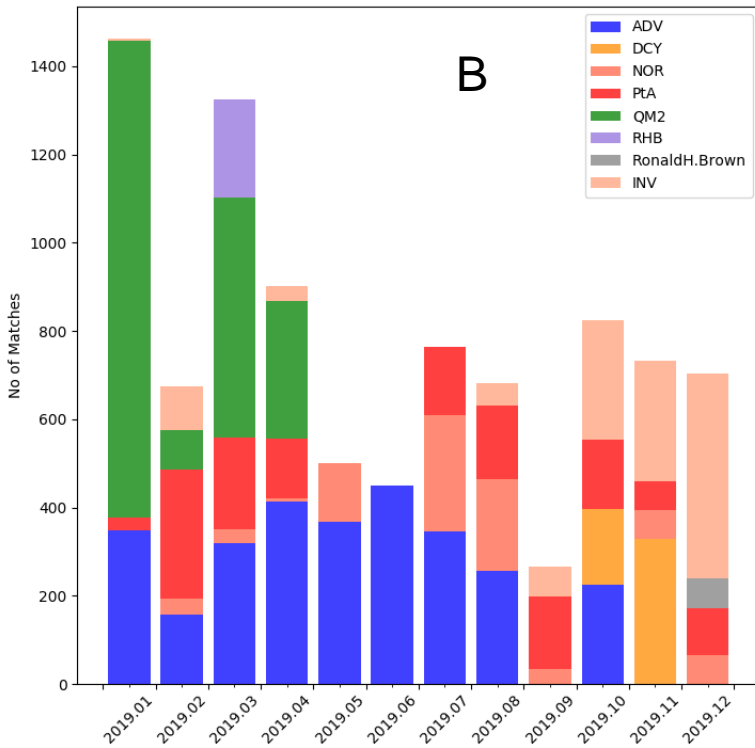
Night						
Grade	MDif f	RSD	No	Overpass	Min Temp	Max Tem
1	0.05	0.19	1297	141	273.75	305.08
2a	0.03	0.26	3907	258	273.25	305.88
<b>2b</b>	<b>0.05</b>	<b>0.21</b>	<b>5164</b>	<b>215</b>	<b>273.29</b>	<b>305.08</b>
3	0.04	0.27	15297	321	273.17	306.05
4	0.03	0.29	42267	391	273.15	306.05

Night						
Grade	MDif f	RSD	No	Overpass	Min Temp	Max Tem
1	0.01	0.17	1491	158	273.22	303.20
2a	0.03	0.23	4152	271	273.18	305.80
<b>2b</b>	<b>0.03</b>	<b>0.19</b>	<b>5630</b>	<b>229</b>	<b>273.22</b>	<b>304.47</b>
3	0.03	0.25	16069	332	273.15	305.80
4	0.00	0.29	43722	412	273.15	305.80

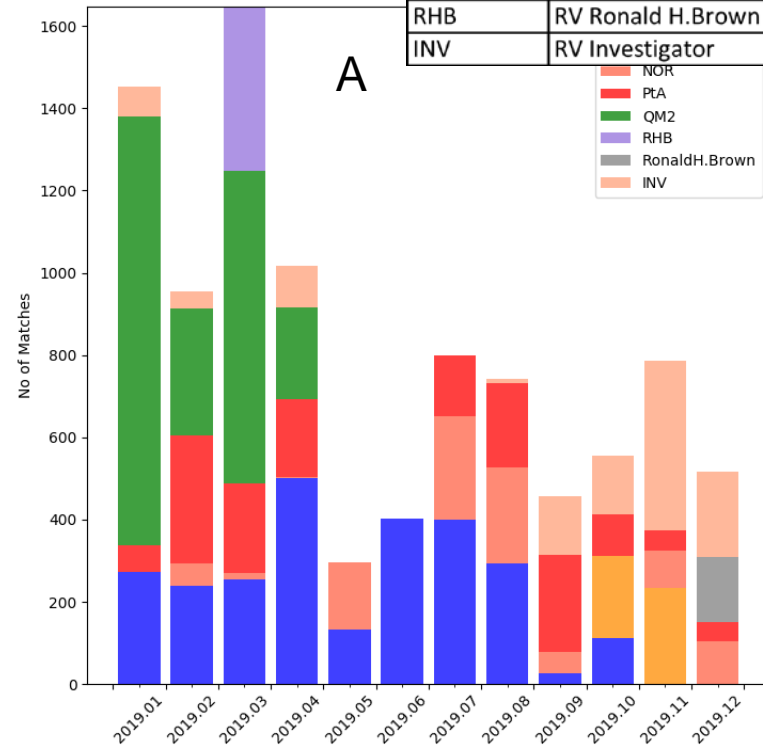
# Validation results – RDAC split

■ 2019

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



s4sstr1l1, all, sstdiff\_sst\_wst, grade 2b, all, ghrsst-all, qi-all - HuberT processed 20210604 (c) 2021 ISAR team - v5.3



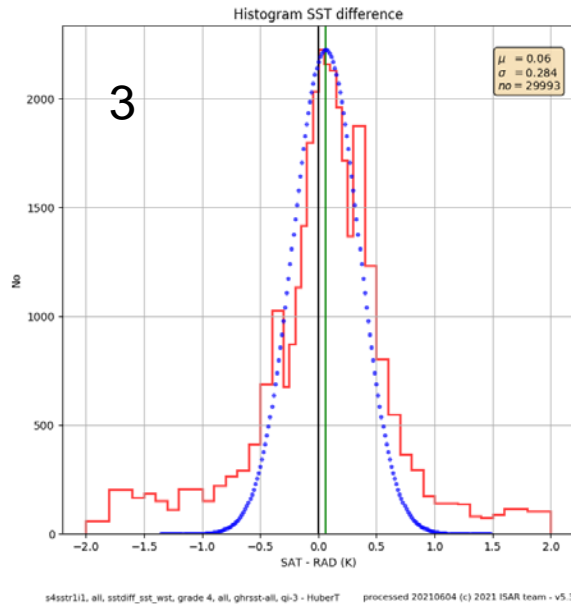
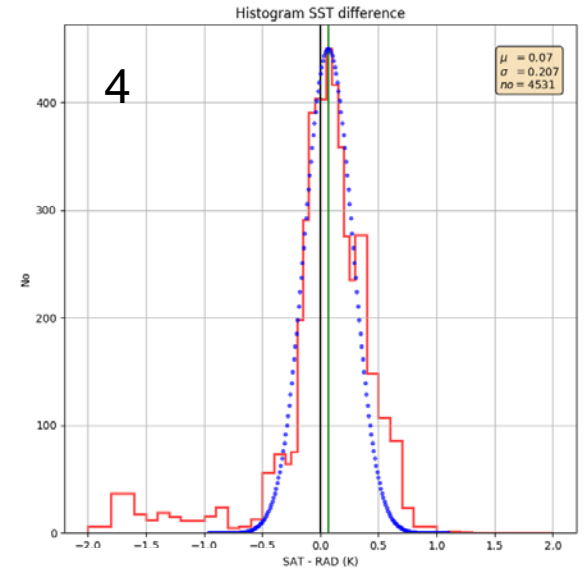
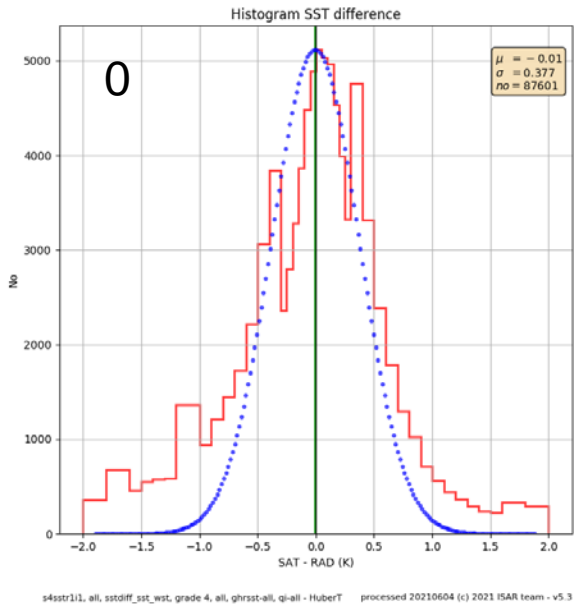
s4sstr1l1, all, sstdiff\_sst\_wst, grade 2b, all, ghrsst-all, qi-all - HuberT processed 20210604 (c) 2021 ISAR team - v5.3

# Validation results - QI

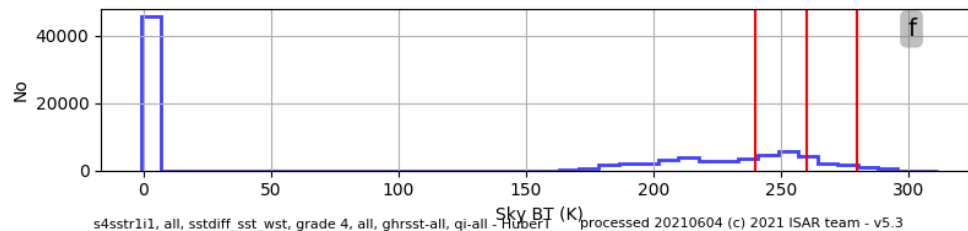
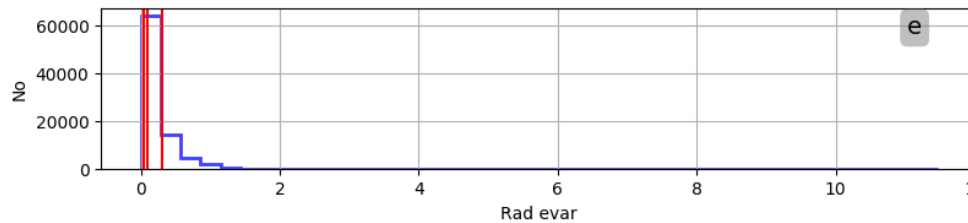
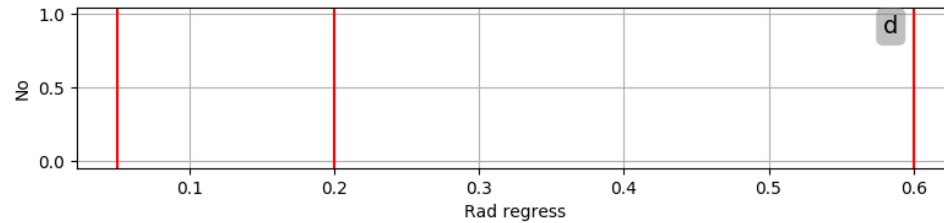
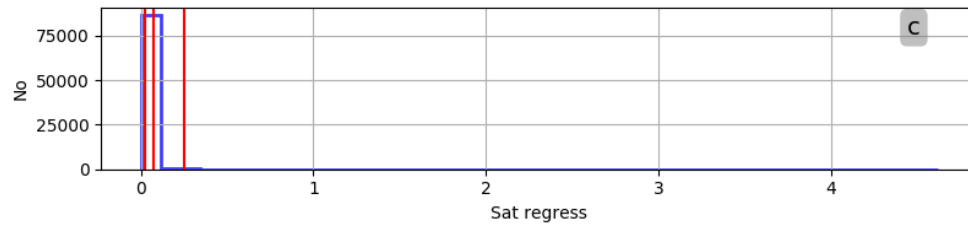
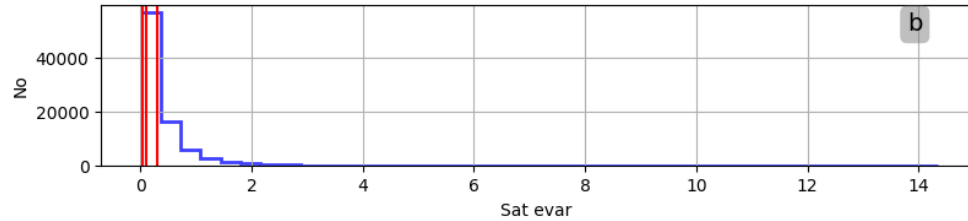
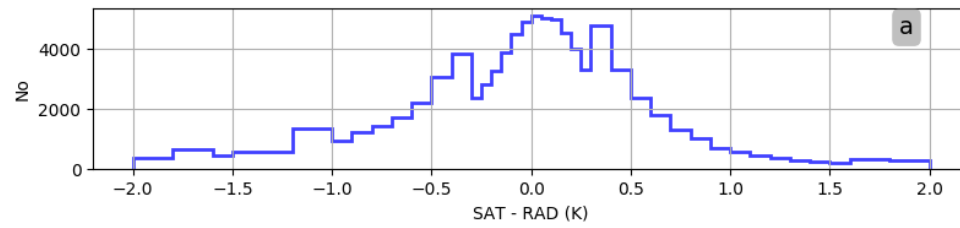
- Estimateing match-up uncertainty :
  - $\sigma = \sigma_S + \sigma_T + \sigma_M + \sigma_P + \sigma_Z$
  - $\sigma = \sigma_S + \sigma_T + (\sigma_{PS} + \sigma_{PR})$
- Reprocessed data - August 2016 – April 2018
- Five indicators:
  - Satellite variability – de-trended 9x9 field around match, weighted 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

5



# Histogram Q1



ships4sst: FRM4SST



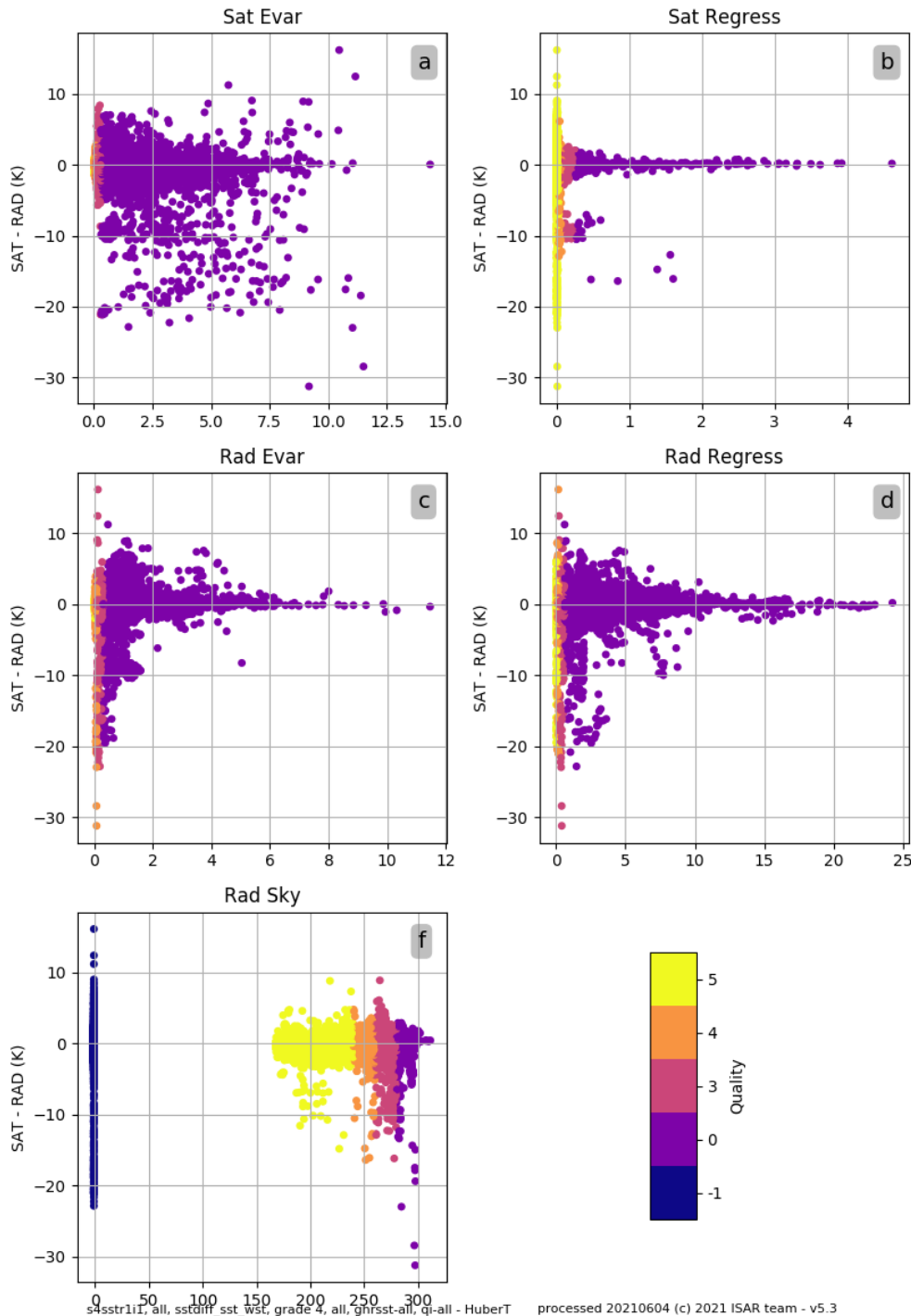
May 2020  
September  
122

DMI  
Vejr, klima og hav

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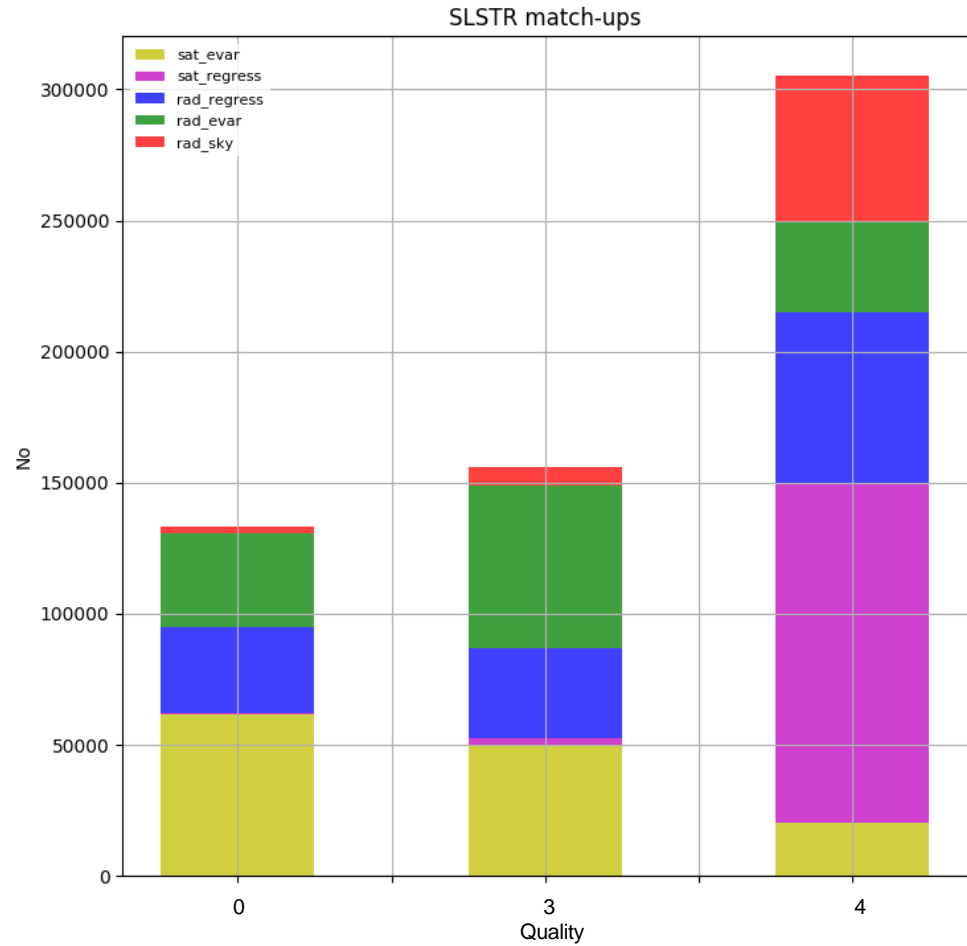


# Validation scatter – (





# Validation – Q1



all, sstdiff\_sst\_wst, grade 4, all, ghrsst-all, qi-all - HuberT

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

# Validation results – statistics

- 2019 S3A

Day							
QI	MDif f	RSD	No	Overpass	Min Temp	Max Tem	
0	0.03	0.37	26331	300	273.15	308.01	
3	0.08	0.31	8680	158	273.15	305.93	
4	0.04	0.14	743	42	273.62	303.64	
5							

WST							
All							
QI	MDif f	RSD	No	Overpass	Min Temp	Max Tem	
0	0.03	0.32	68598	691	273.15	308.01	
3	0.06	0.25	23421	426	273.15	305.93	
4	0.08	0.18	2467	120	273.22	305.15	
5							

Night							
QI	MDif f	RSD	No	Overpass	Min Temp	Max Tem	
0	0.03	0.29	42267	391	273.15	306.05	
3	0.05	0.23	14741	268	273.17	305.22	
4	0.10	0.17	1724	78	273.22	305.15	
5							

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

- 2019 - S3A, all, CV5, D3, N3 excluded in day time

D3					N3						
Night					Night						
Grade	MDiff	RSD	No	Overpass	Grade	MDiff	RSD	No	Overpass	Min Temp	Max Temp
1	-0.13	0.15	118	59	1	-0.05	0.15	262	59	273.36	300.38
2a	-0.12	0.30	329	100	2a	-0.08	0.20	540	100	273.36	300.93
<b>2b</b>	<b>-0.08</b>	<b>0.17</b>	<b>447</b>	<b>82</b>	<b>2b</b>	<b>-0.04</b>	<b>0.16</b>	<b>944</b>	<b>82</b>	<b>273.36</b>	<b>301.08</b>
3	-0.12	0.32	1296	116	3	-0.08	0.22	2196	116	273.23	301.68
4	-0.16	0.39	3867	174	4	-0.10	0.29	6479	174	273.05	302.68

D2					N2						
Day					Day						
Grade	MDiff	RSD	No	Overpass	Grade	MDiff	RSD	No	Overpass	Min Temp	Max Temp
1	0.02	0.21	64	24	1	0.00	0.19	97	24	276.54	302.66
2a	-0.31	0.77	303	53	2a	-0.46	0.38	348	53	273.21	302.73
<b>2b</b>	<b>-0.22</b>	<b>0.43</b>	<b>307</b>	<b>44</b>	<b>2b</b>	<b>-0.11</b>	<b>0.30</b>	<b>432</b>	<b>44</b>	<b>273.21</b>	<b>302.66</b>
3	-0.95	0.90	1158	73	3	-0.42	0.47	1352	73	273.17	302.77
4	-0.39	0.73	3428	130	4	-0.34	0.52	4069	130	273.12	303.51

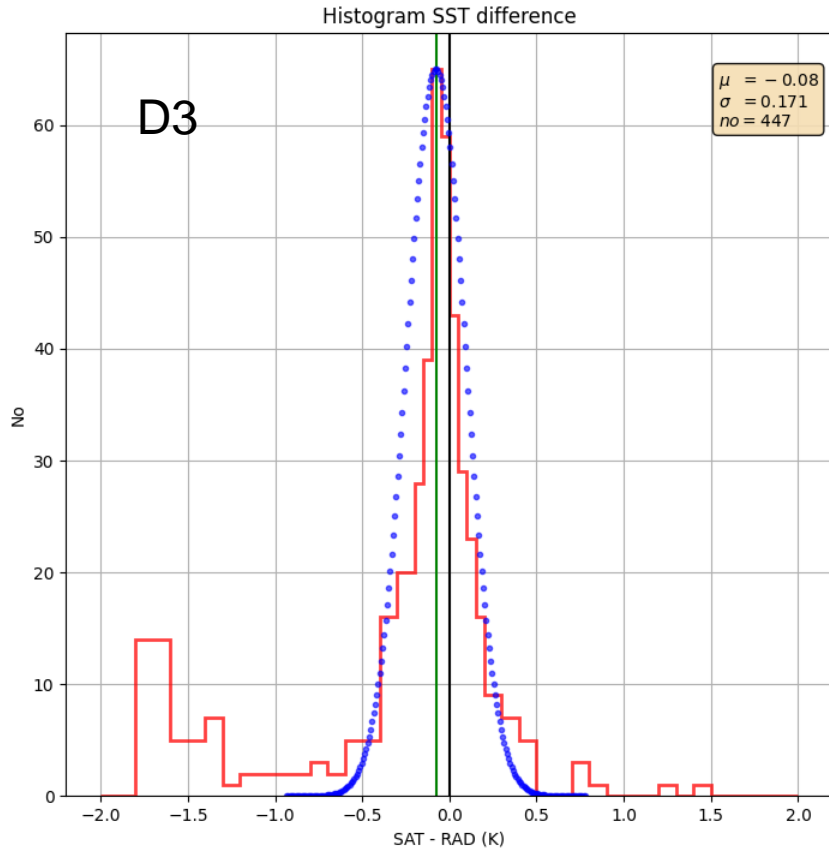
D2					N2						
Night					Night						
Grade	MDiff	RSD	No	Overpass	Grade	MDiff	RSD	No	Overpass	Min Temp	Max Temp
1	-0.19	0.25	118	59	1	-0.08	0.20	262	59	273.32	301.31
2a	-0.16	0.34	329	100	2a	-0.15	0.27	540	100	273.32	301.71
<b>2b</b>	<b>-0.13</b>	<b>0.21</b>	<b>447</b>	<b>82</b>	<b>2b</b>	<b>-0.08</b>	<b>0.20</b>	<b>944</b>	<b>82</b>	<b>273.32</b>	<b>301.75</b>
3	-0.16	0.33	1296	116	3	-0.13	0.31	2196	116	273.20	302.24
4	-0.19	0.40	3867	174	4	-0.11	0.44	6479	174	273.03	303.54

ships4sst: FRM4SST

FRM4SST: ISFRN wc

# Validation results – D3,D2

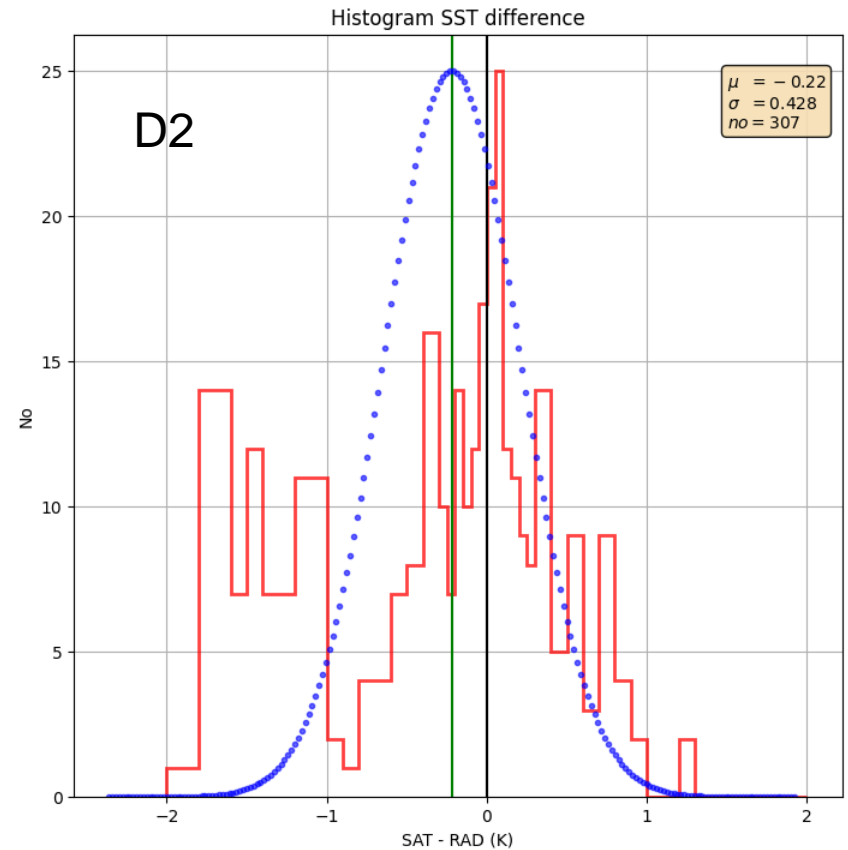
- S3A, Grade 2b, CV5, same pixel, night, day



s4sstr1i1, all, sstdiff\_D3, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20220907 (c) 2022 ISAR team - v5.5

ships4sst: FRM4SST

FRM4SST: ISFRN workshop – validation



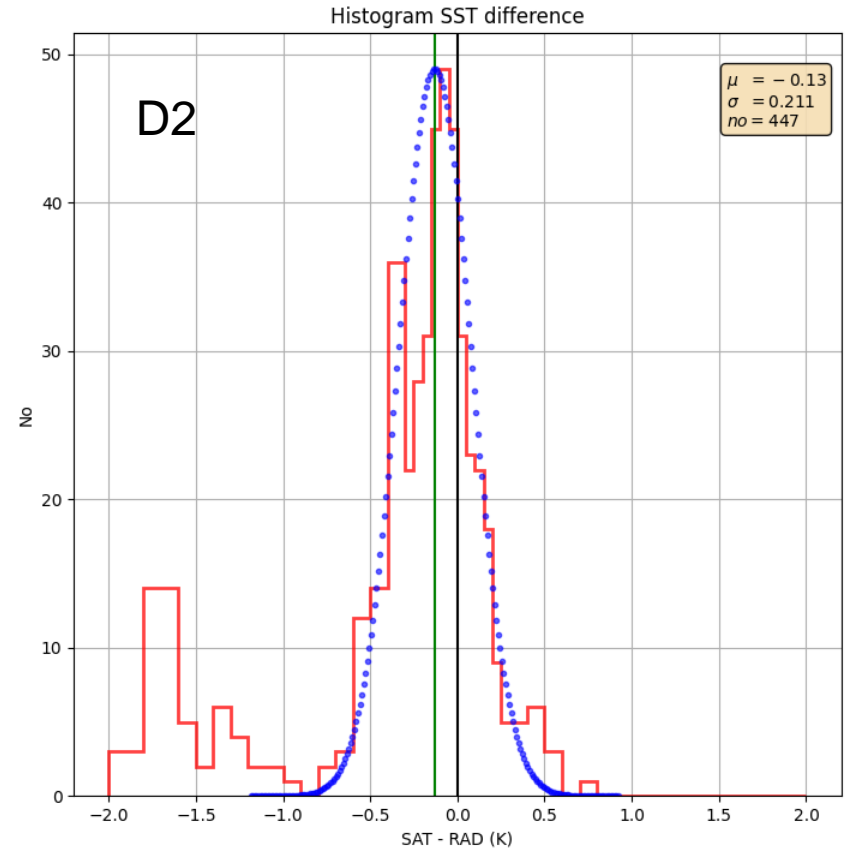
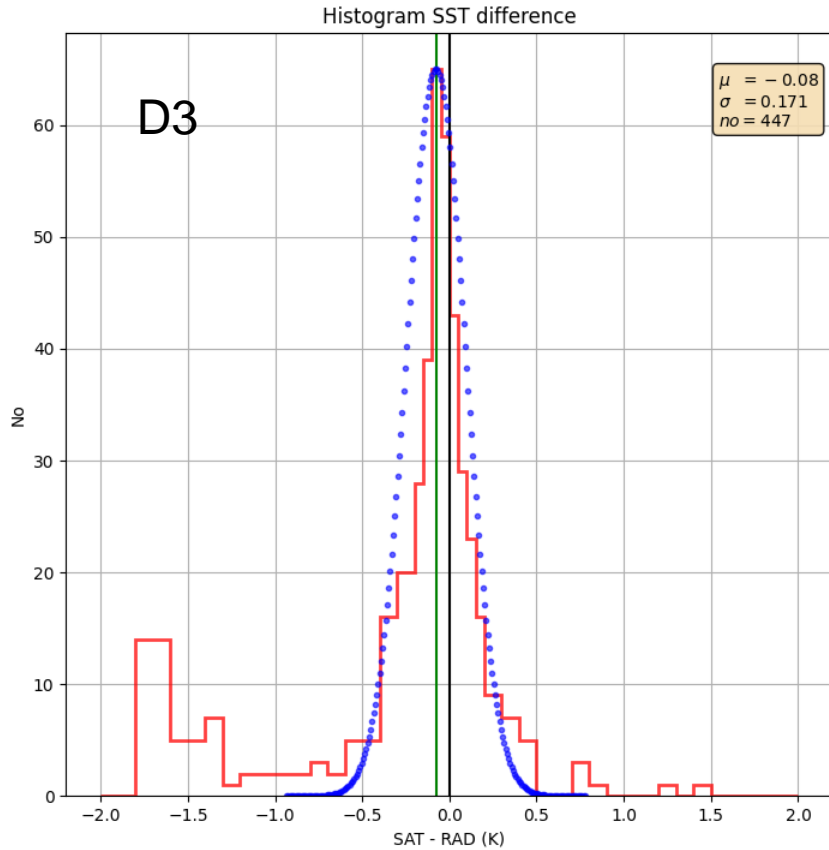
s4sstr1i1, all, sstdiff\_D2, grade 2b, day, ghrsst-5, qi-all - HuberT processed 20220907 (c) 2022 ISAR team - v5.5

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# Validation results – D3,D2

- S3A, Grade 2b, CV5, same pixel, both night

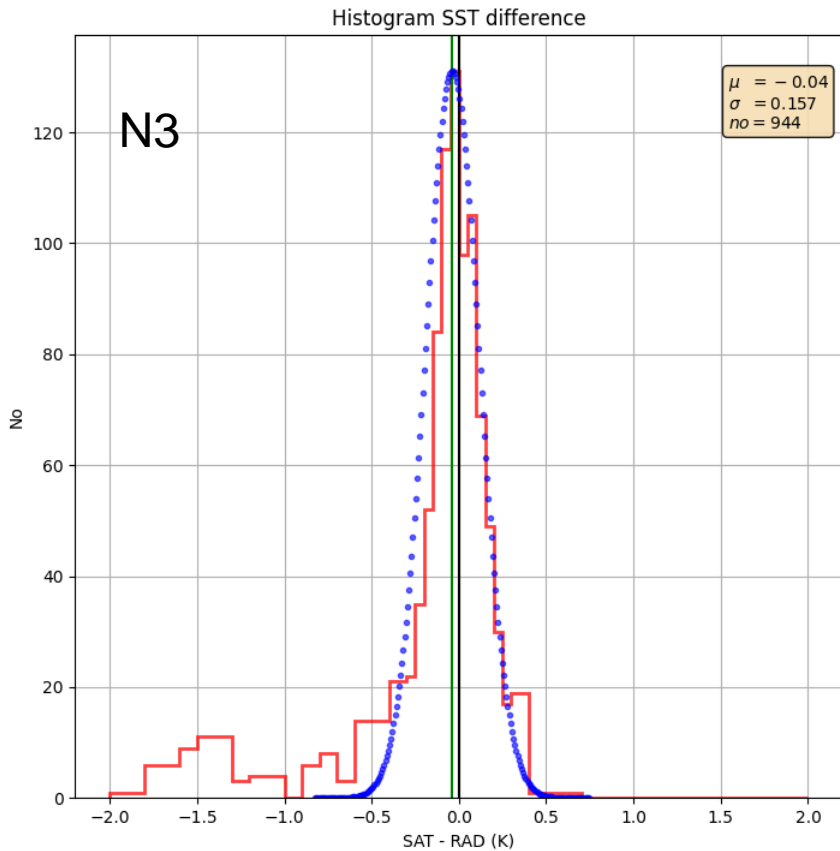


s4sstr111, all, sstdiff\_D3, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20220907 (c) 2022 ISAR team - v5.5

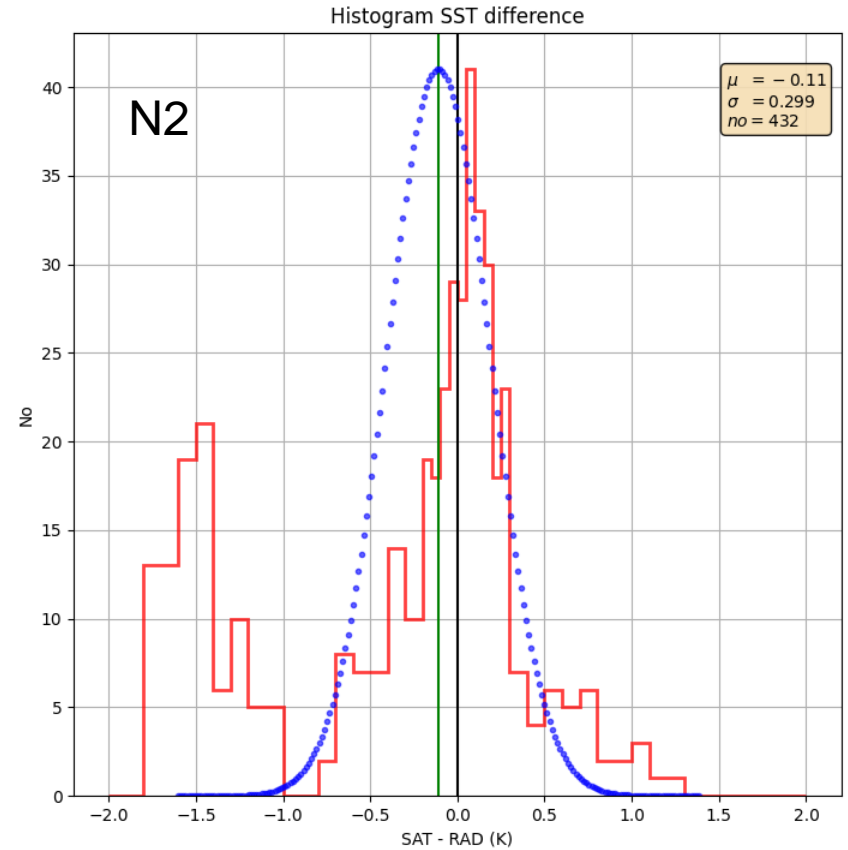
s4sstr111, all, sstdiff\_D2, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20220907 (c) 2022 ISAR team - v5.5

# Validation results – N3, N2

- S3A, Grade 2b, CV5, same pixel, night day



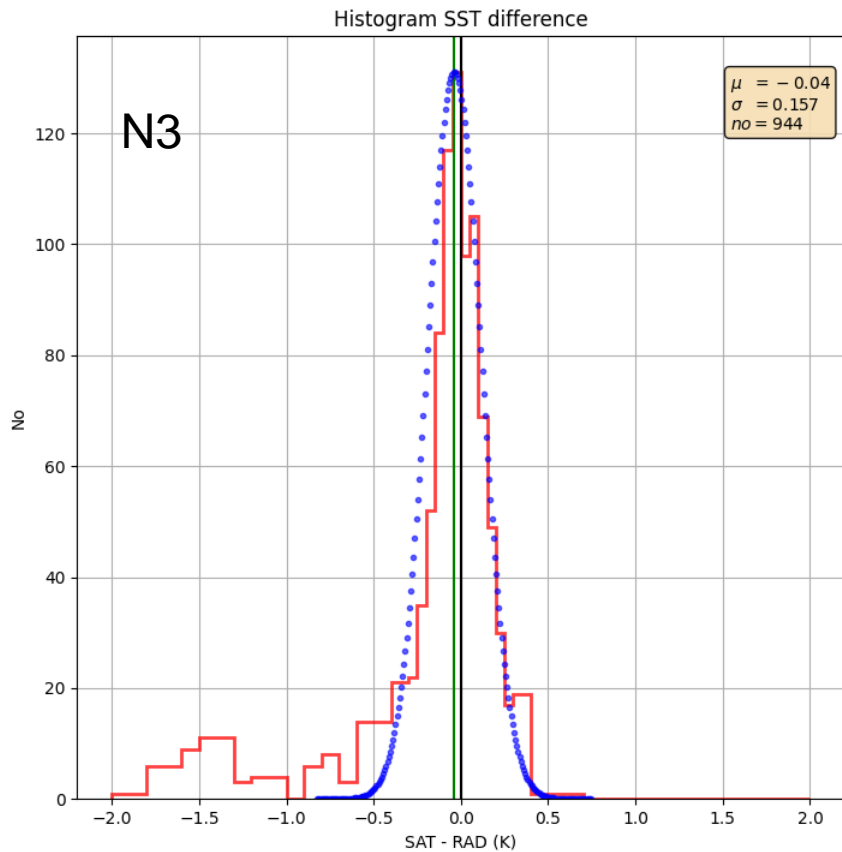
s4sstr1i1, all, sstdiff\_N3, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20220907 (c) 2022 ISAR team - v5.5



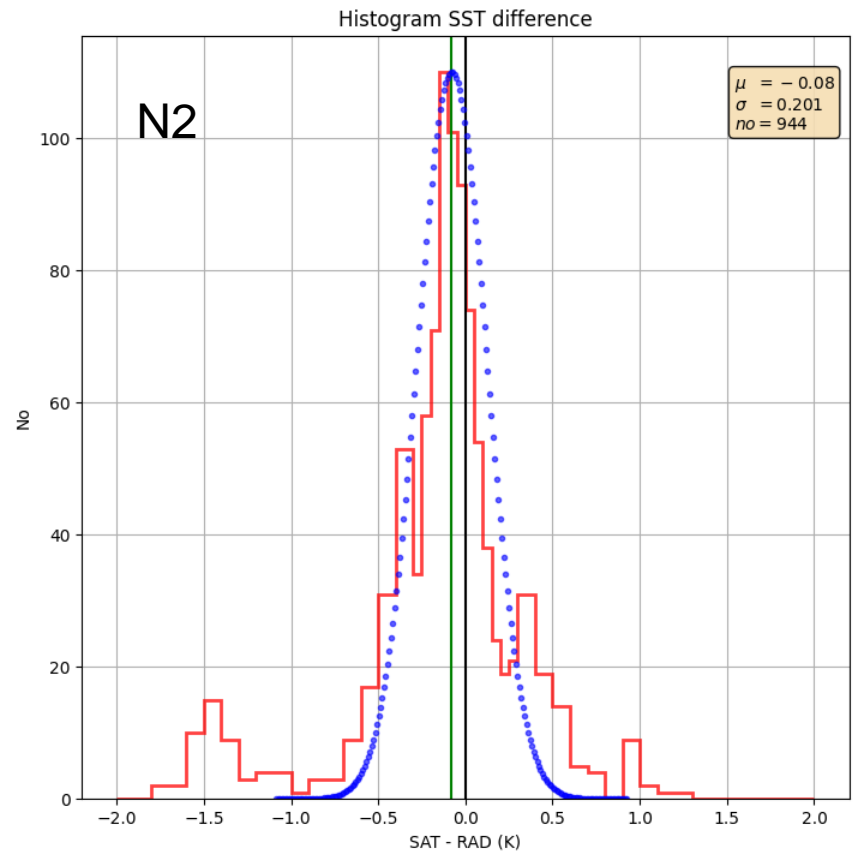
s4sstr1i1, all, sstdiff\_N2, grade 2b, day, ghrsst-5, qi-all - HuberT processed 20220907 (c) 2022 ISAR team - v5.5

# Validation results – N3, N2

- S3A, Grade 2b, CV5, same pixel, both night



s4sstr1i1, all, sstdiff\_N3, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20220907 (c) 2022 ISAR team - v5.5



s4sstr1i1, all, sstdiff\_N2, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20220907 (c) 2022 ISAR team - v5.5

# 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