



ships4sst

shipborne radiometers for sea surface temperature

Using ships4sst data to validate SLSTR data

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Kelliher, C. Donlon

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



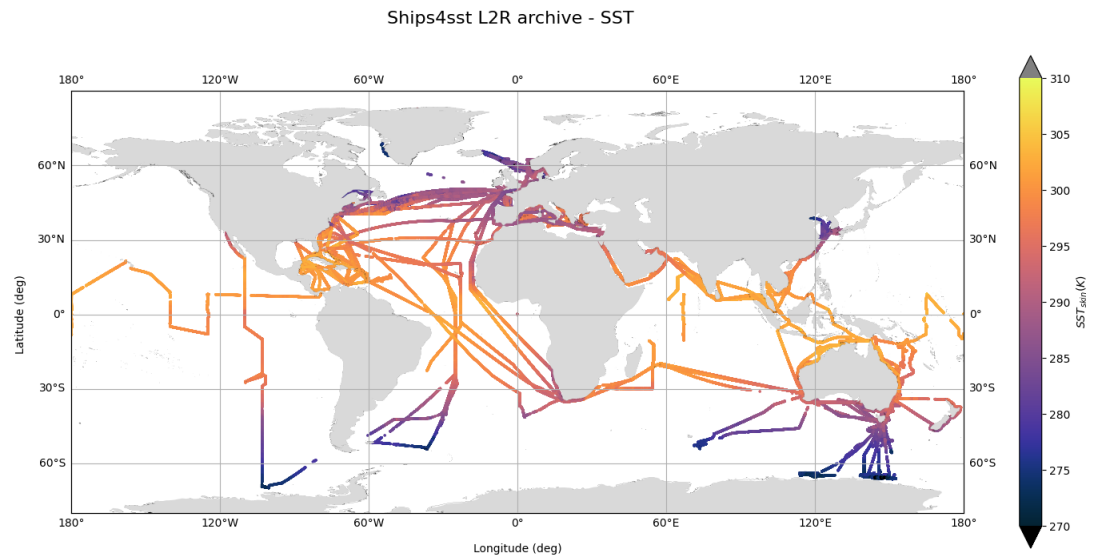
Outline

- Introduction
 - Data sources and processing
 - Validation methods
- Validation Results
 - NRT 2020 - 2022 – WST
 - Results per year - WST
 - D3, D2, N3, N2 results for the 2020 - 2022 data
- Conclusion



Data

- SLSTR
 - NRT data 2020, 2021, 2022
- FRM
 - Radiometer data from ships4sst
- The MDB files are produced by Felyx
 - SLSTR L1b and L2 data within 400x400 pixels of match-up
 - L2R data within 6hrs of match-up



Validation methods

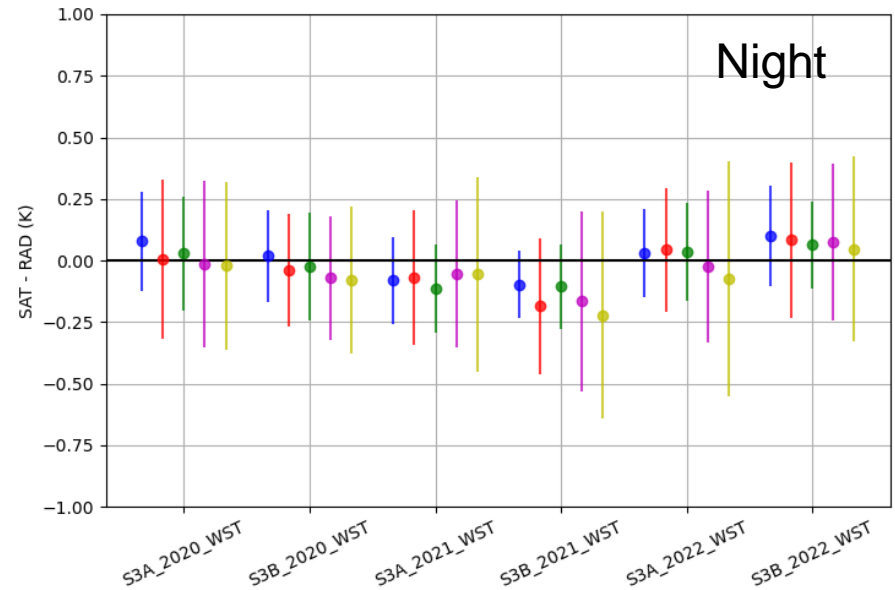
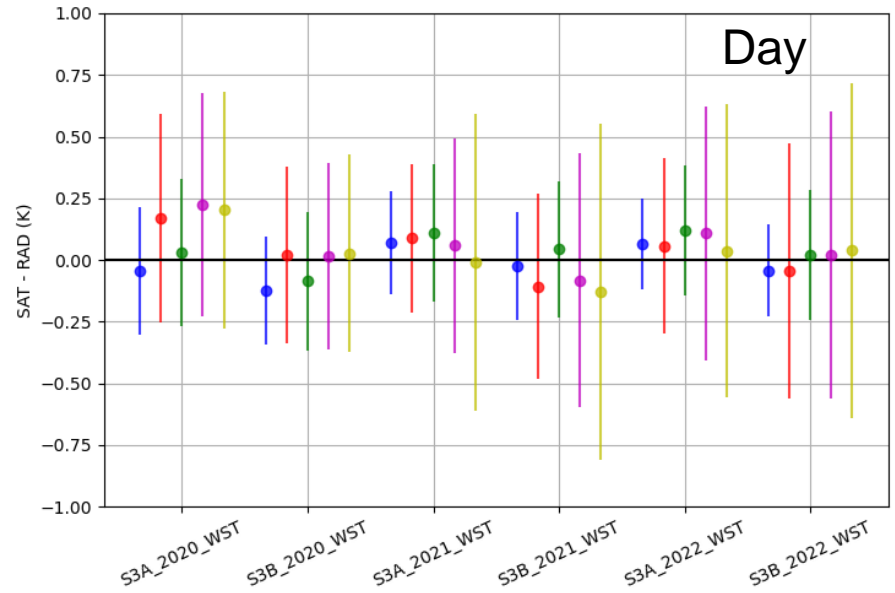
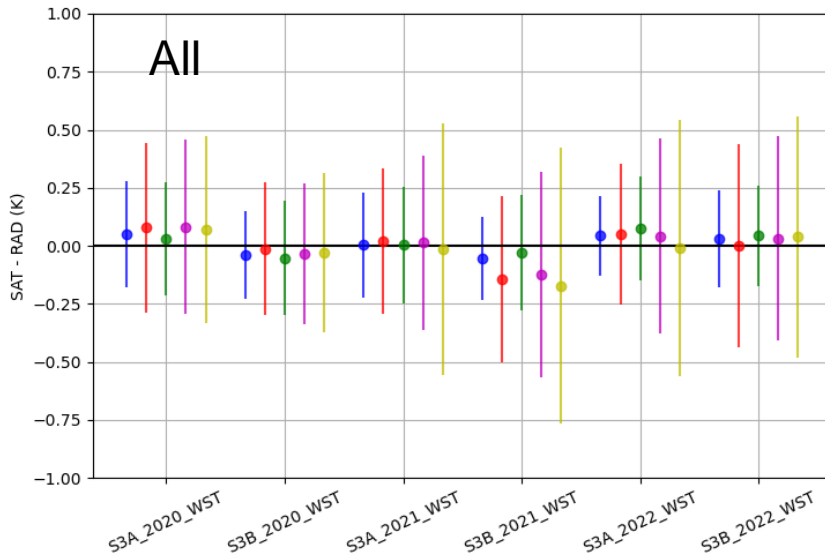
- MDB files (as produced by felyx) are reprocessed
 - allow multiple matches per match-up location (overpass)
 - Validate WST, D3, D2, N3, N2 and all GHR SST CV levels (0, 3,4,5)
 - Results are only shown for GHR SST CV 5 (best quality)
 - follow the Wimmer et.al. 2012 approach.
- Wimmer et. al. 2012:
 - Match-up grades

| grade | temporal (h) | spatial (km) | colour |
|-------|--------------|--------------|---------|
| 1 | 0.5 | 1 | blue |
| 2a | 0.5 | 20 | red |
| 2b | 2.0 | 1 | green |
| 3 | 2.0 | 20 | magenta |
| 4 | 6.0 | 25 | yellow |

Wimmer, W., Robinson, I. S., & Donlon, C. J. (2012). [Long-term validation of AATSR SST data products using shipborne radiometry in the Bay of Biscay and English Channel](#). *Remote Sensing of Environment*, 116, 17-31. DOI: [10.1016/j.rse.2011.03.022](https://doi.org/10.1016/j.rse.2011.03.022)

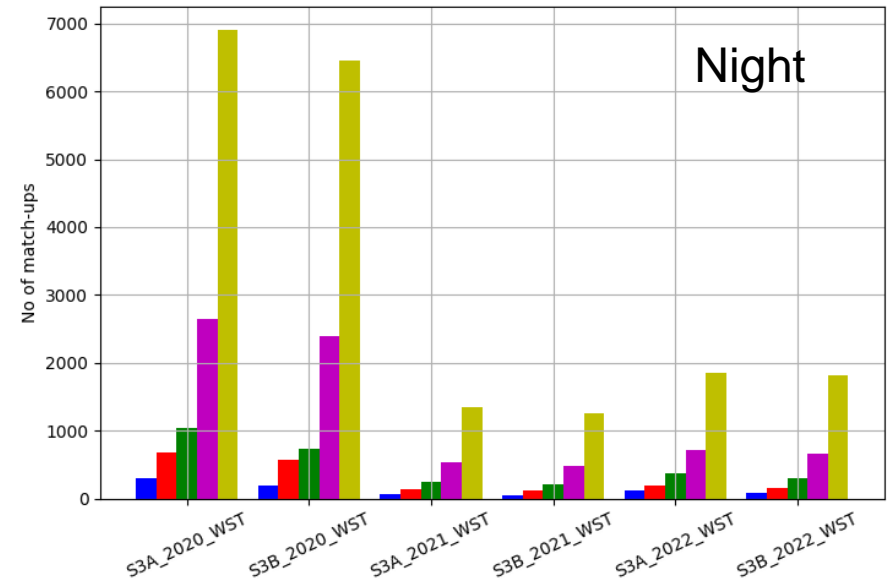
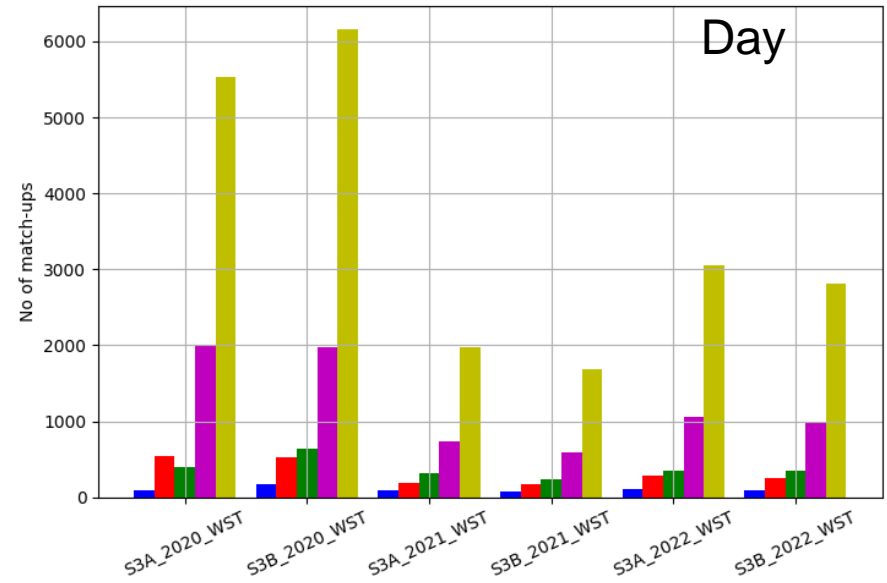
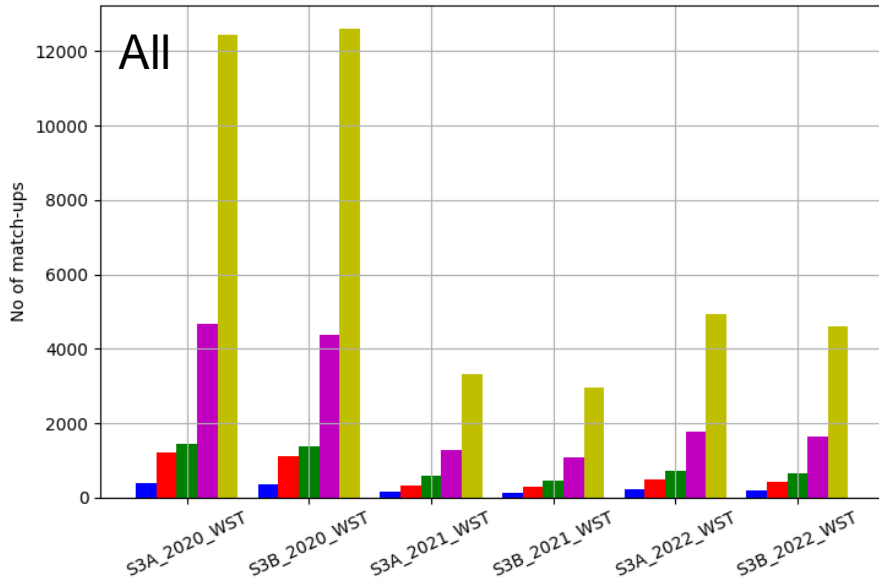
Validation results - g

- WST – 2020 - 2022, CV 5



Validation results - gl

- WST – 2020 - 2022, CV 5

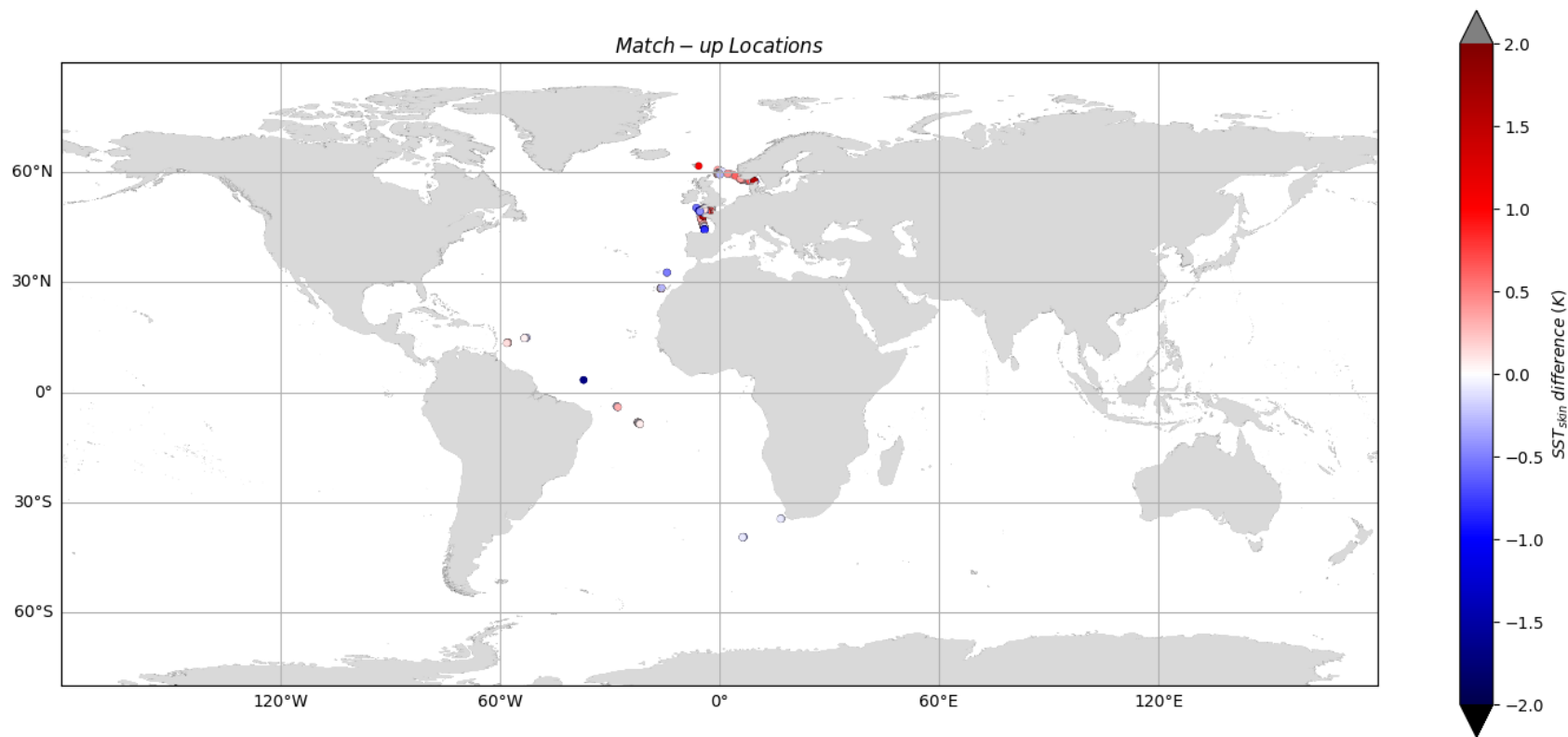


ships4sst

SLSTR validation with ships4sst

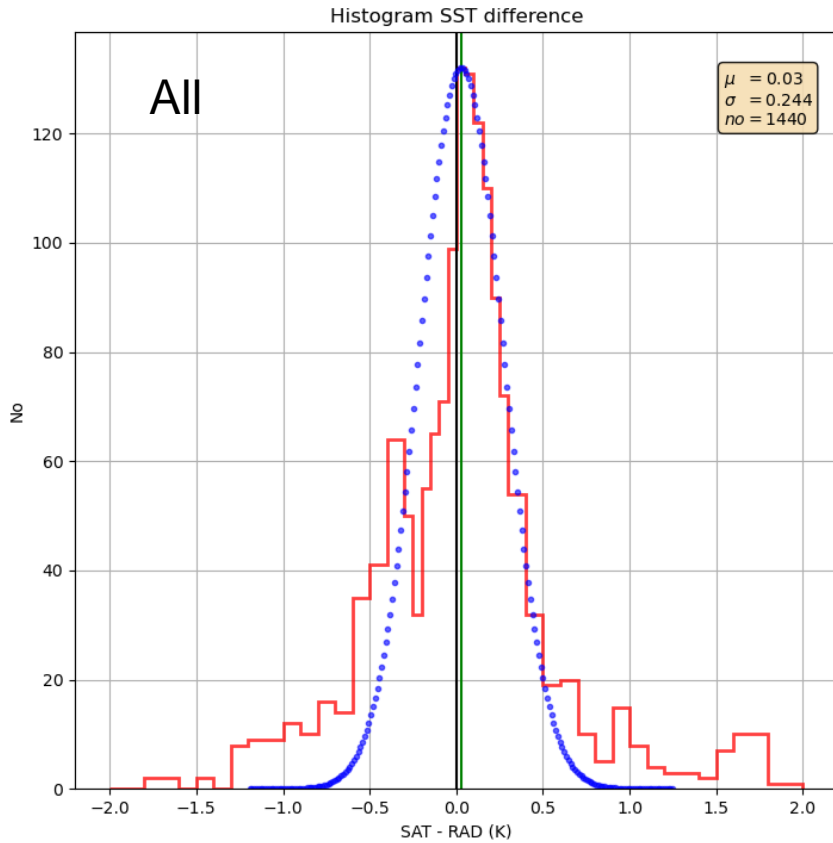
Validation results - global

- WST - 2020, CV5, grade 2b - S3A



Histograms – CV5

2020 – S3A

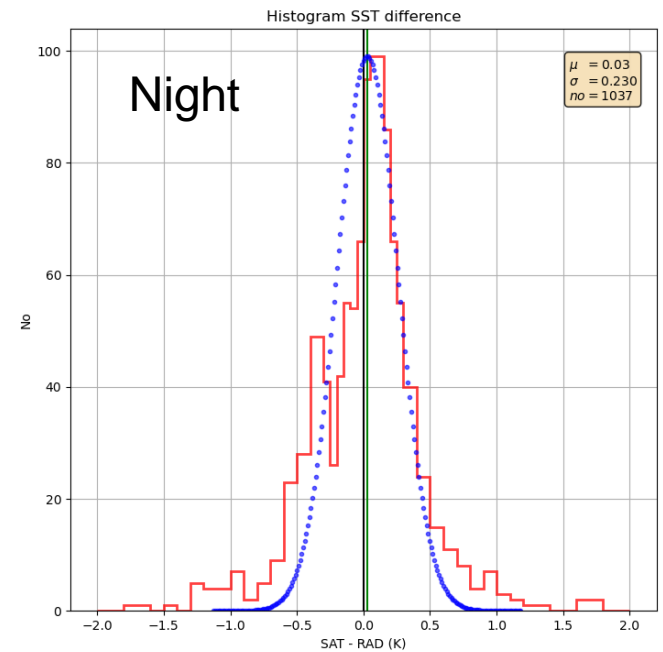
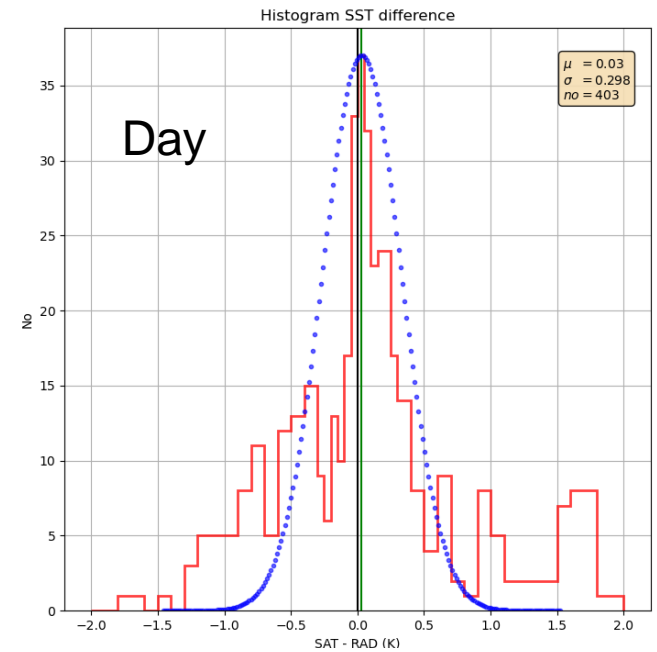


S3A_2020_wst_grade2b_all_ghrsst-5_qi-all

processed 20231206 (c) 2023 ISAR team - v2.1

ships4sst

SLSTR validation with ships4sst data

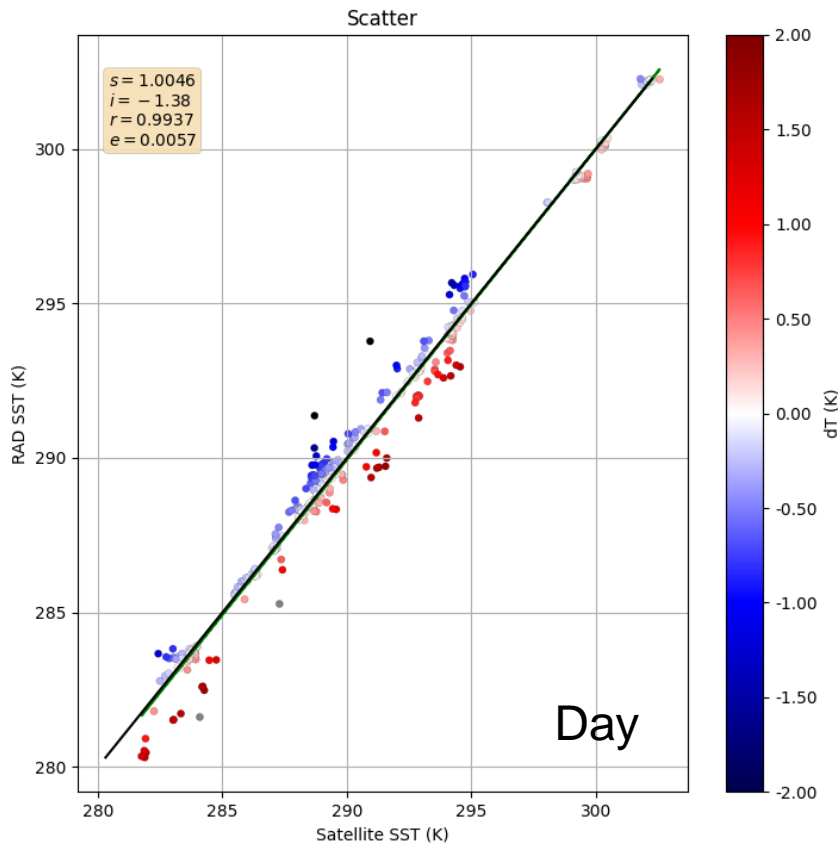


S3A_2020_wst_grade2b_night_ghrsst-5_qi-all

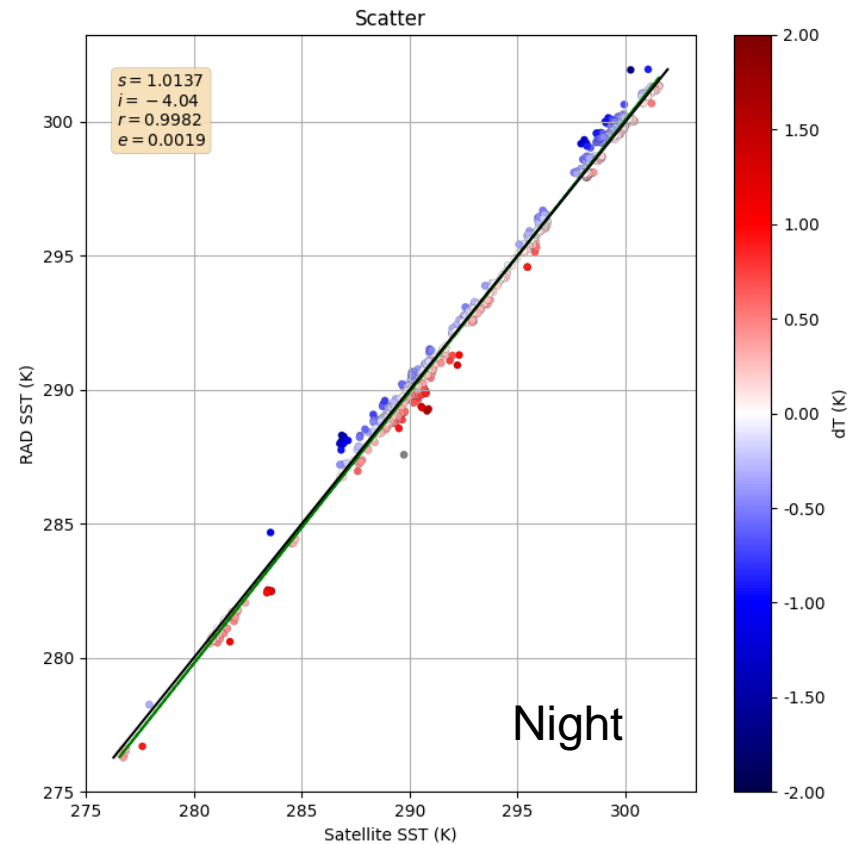
processed 20231206 (c) 2023 ISAR team - v2.1

Validation – scatter, CV 5

2020 - S3A



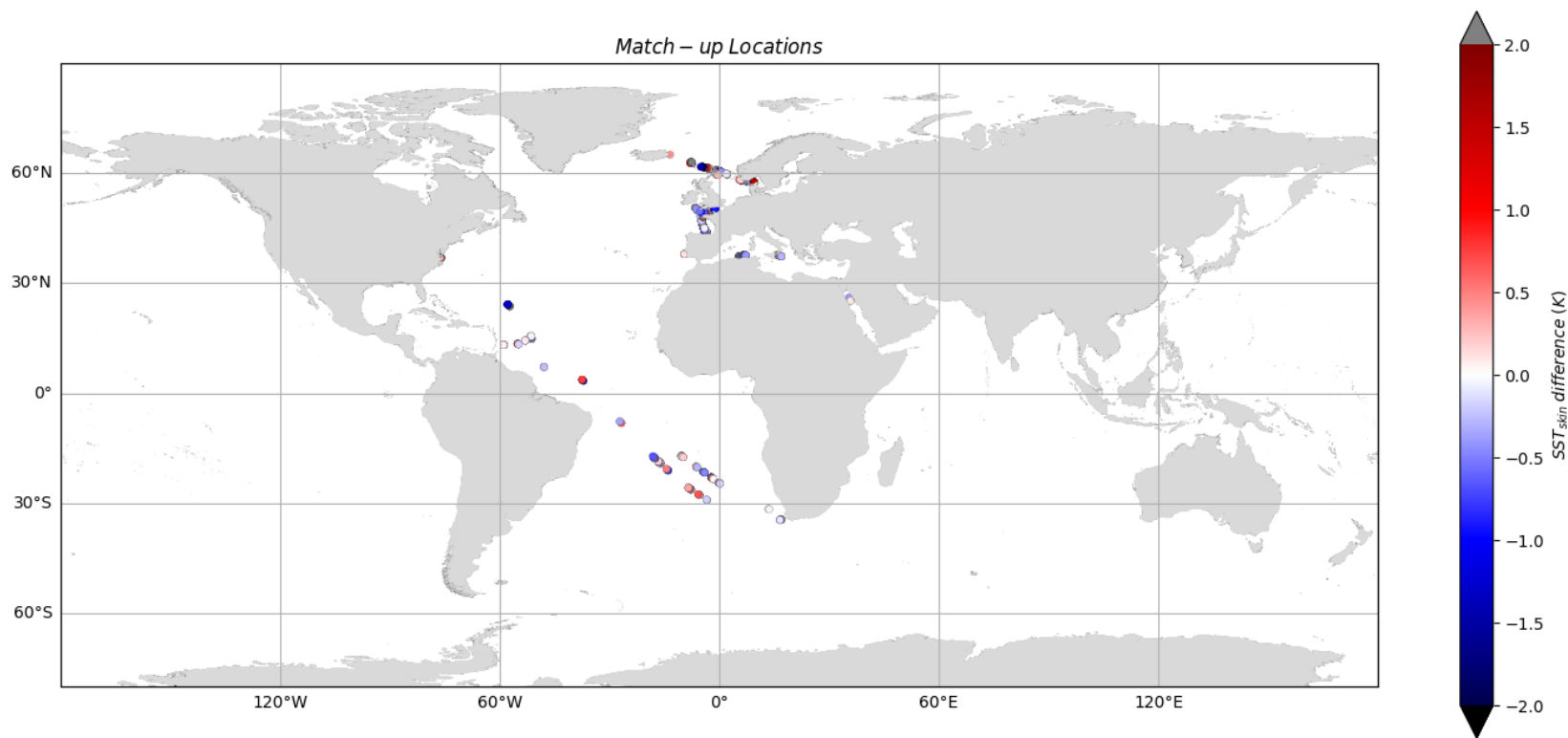
s4sstr1i1, all, sstdiff_sst_wst, grade 2b, day, ghrsst-5, qi-all - HuberT processed 20231117 (c) 2023 ISAR team - v6.1



s4sstr1i1, all, sstdiff_sst_wst, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20231117 (c) 2023 ISAR team - v6.1

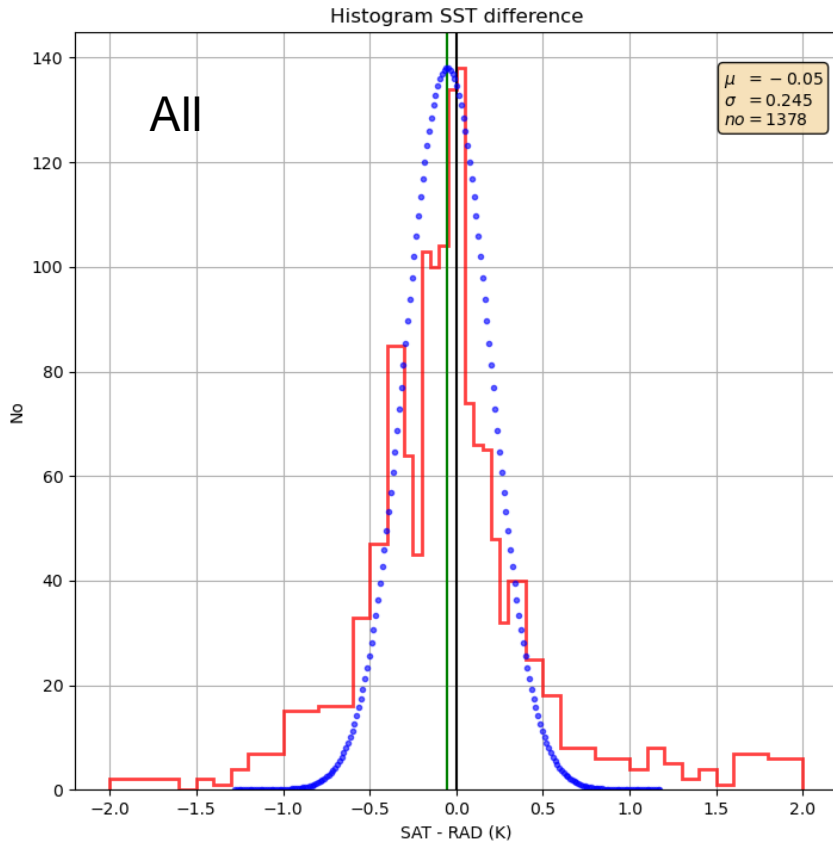
Validation results - global

- WST - 2020, CV5, grade 2b - S3B



Histograms – CV5

2020 - S3B

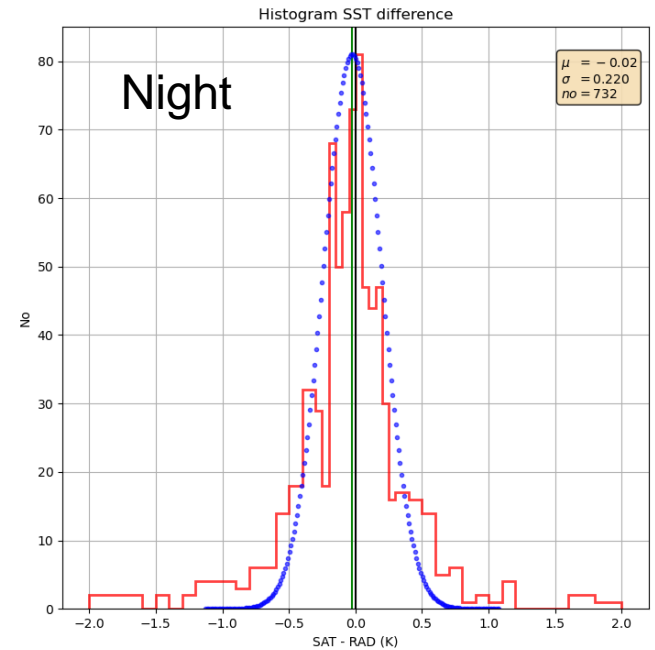
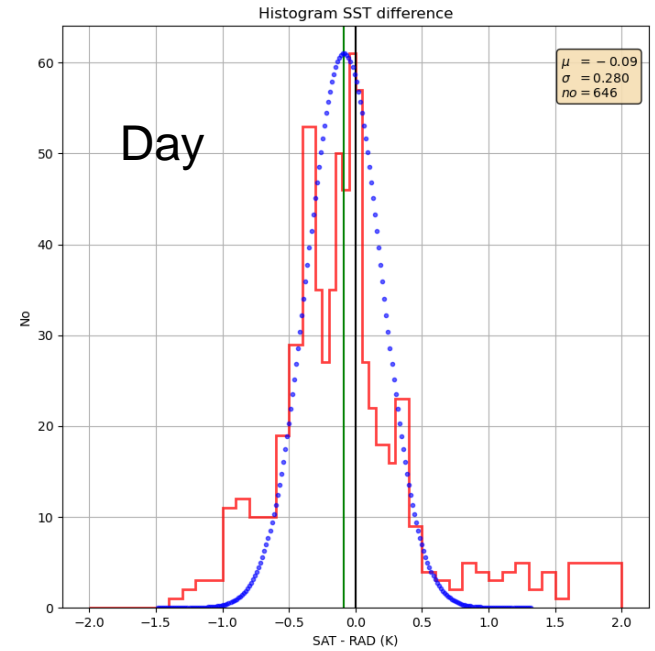


S3B_2020_wst_grade2b_all_ghrsst-5_qi-all

processed 20231206 (c) 2023 ISAR team - v2.1

ships4sst

SLSTR validation with ships4sst data

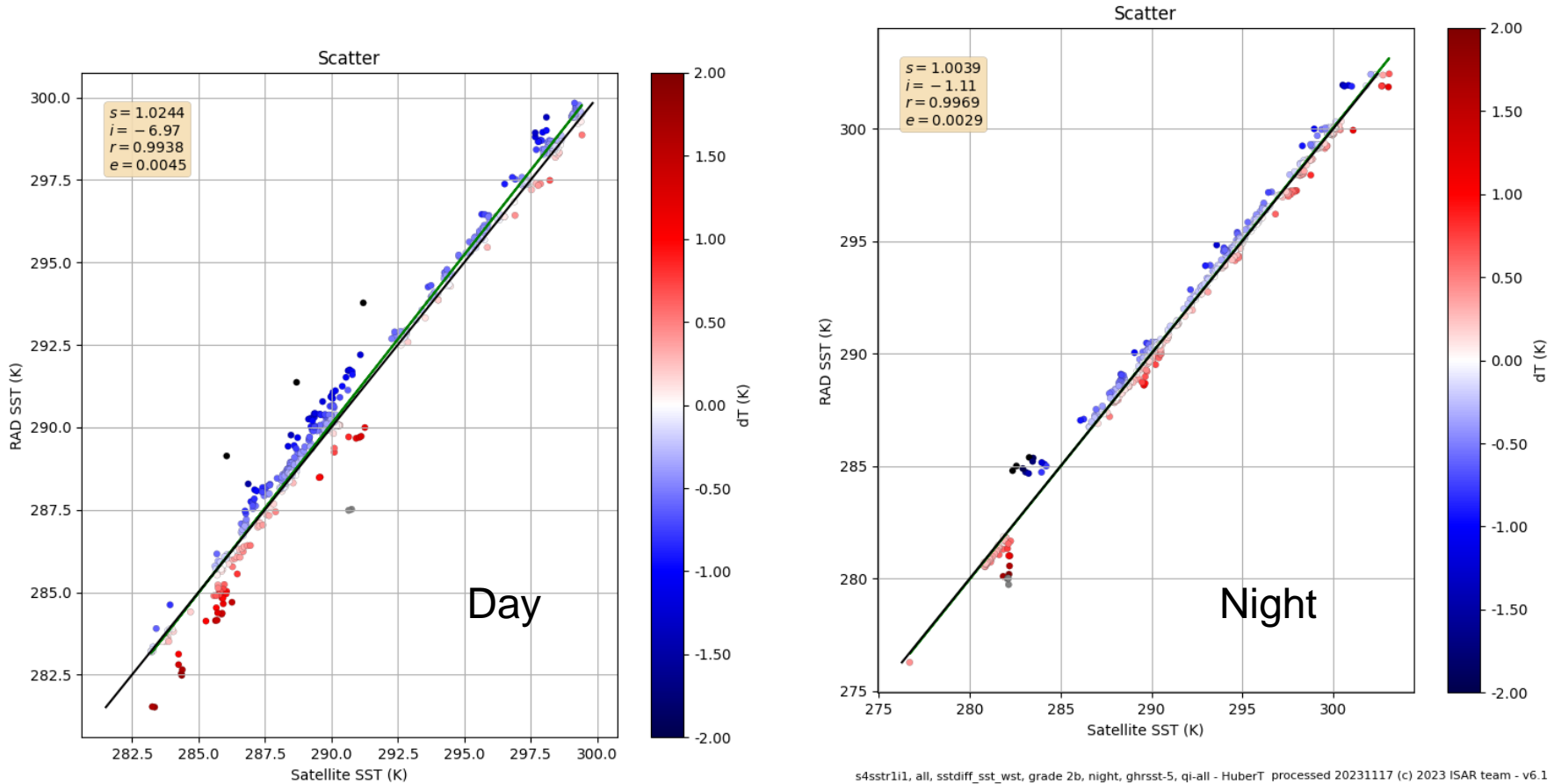


S3B_2020_wst_grade2b_night_ghrsst-5_qi-all

processed 20231206 (c) 2023 ISAR team - v2.1

Validation – scatter, CV 5

2020 - S3B



s4sstr1i1, all, sstdiff_sst_wst, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20231117 (c) 2023 ISAR team - v6.1

s4sstr1i1, all, sstdiff_sst_wst, grade 2b, day, ghrsst-5, qi-all - HuberT processed 20231117 (c) 2023 ISAR team - v6.1

23. April 2024

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Validation results – statistics

B

- 2020 – S3 A vs B – WST CV5

A

| Day | | | | | | |
|-----------|-------------|-------------|------------|-----------|---------------|---------------|
| Grade | MDif f | RSD | No | Overpass | Min Temp | Max Temp |
| 1 | -0.05 | 0.26 | 96 | 19 | 281.83 | 302.56 |
| 2a | 0.17 | 0.42 | 538 | 44 | 279.12 | 304.09 |
| 2b | 0.03 | 0.30 | 403 | 31 | 281.83 | 302.56 |
| 3 | 0.22 | 0.45 | 2005 | 57 | 279.12 | 304.14 |
| 4 | 0.20 | 0.48 | 5528 | 103 | 279.12 | 304.98 |

| Night | | | | | | |
|-----------|-------------|-------------|-------------|-----------|---------------|---------------|
| Grade | MDif f | RSD | No | Overpass | Min Temp | Max Temp |
| 1 | 0.08 | 0.20 | 297 | 32 | 277.93 | 301.45 |
| 2a | 0.01 | 0.32 | 686 | 49 | 276.62 | 301.45 |
| 2b | 0.03 | 0.23 | 1037 | 43 | 276.56 | 301.57 |
| 3 | -0.01 | 0.34 | 2656 | 62 | 276.55 | 301.75 |
| 4 | -0.02 | 0.34 | 6908 | 106 | 275.67 | 303.42 |

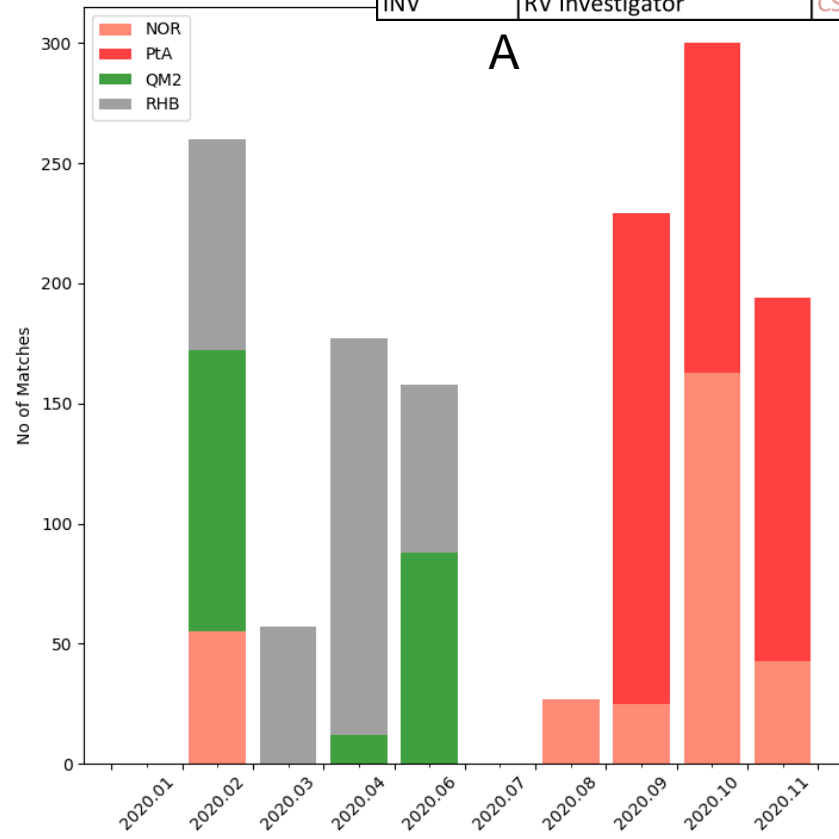
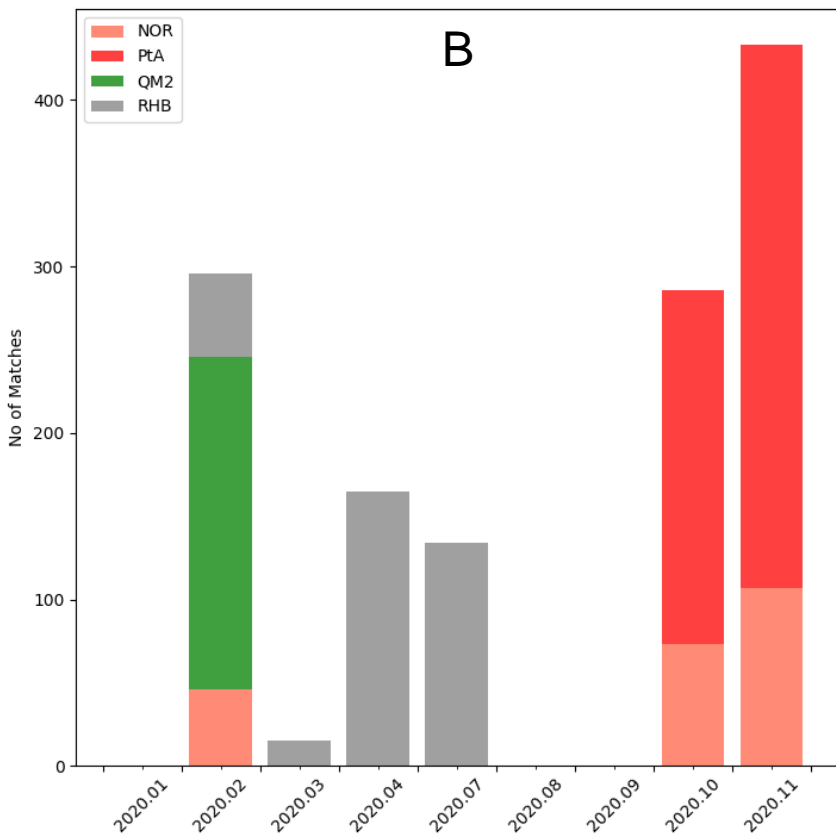
| Day | | | | | | |
|-----------|--------------|-------------|------------|-----------|---------------|---------------|
| Grade | MDif f | RSD | No | Overpass | Min Temp | Max Temp |
| 1 | -0.12 | 0.22 | 167 | 19 | 283.30 | 299.22 |
| 2a | 0.02 | 0.36 | 530 | 42 | 278.64 | 300.63 |
| 2b | -0.09 | 0.28 | 646 | 31 | 283.30 | 299.48 |
| 3 | 0.02 | 0.38 | 1978 | 54 | 278.64 | 303.02 |
| 4 | 0.03 | 0.40 | 6163 | 107 | 278.64 | 304.17 |

| Night | | | | | | |
|-----------|--------------|-------------|------------|-----------|---------------|---------------|
| Grade | MDif f | RSD | No | Overpass | Min Temp | Max Temp |
| 1 | 0.02 | 0.19 | 192 | 28 | 280.73 | 301.07 |
| 2a | -0.04 | 0.23 | 580 | 54 | 279.80 | 303.63 |
| 2b | -0.02 | 0.22 | 732 | 43 | 276.69 | 303.05 |
| 3 | -0.07 | 0.25 | 2386 | 65 | 276.64 | 303.93 |
| 4 | -0.08 | 0.30 | 6448 | 109 | 276.64 | 303.93 |

Validation results – RDAC split

■ 2020

| 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 |

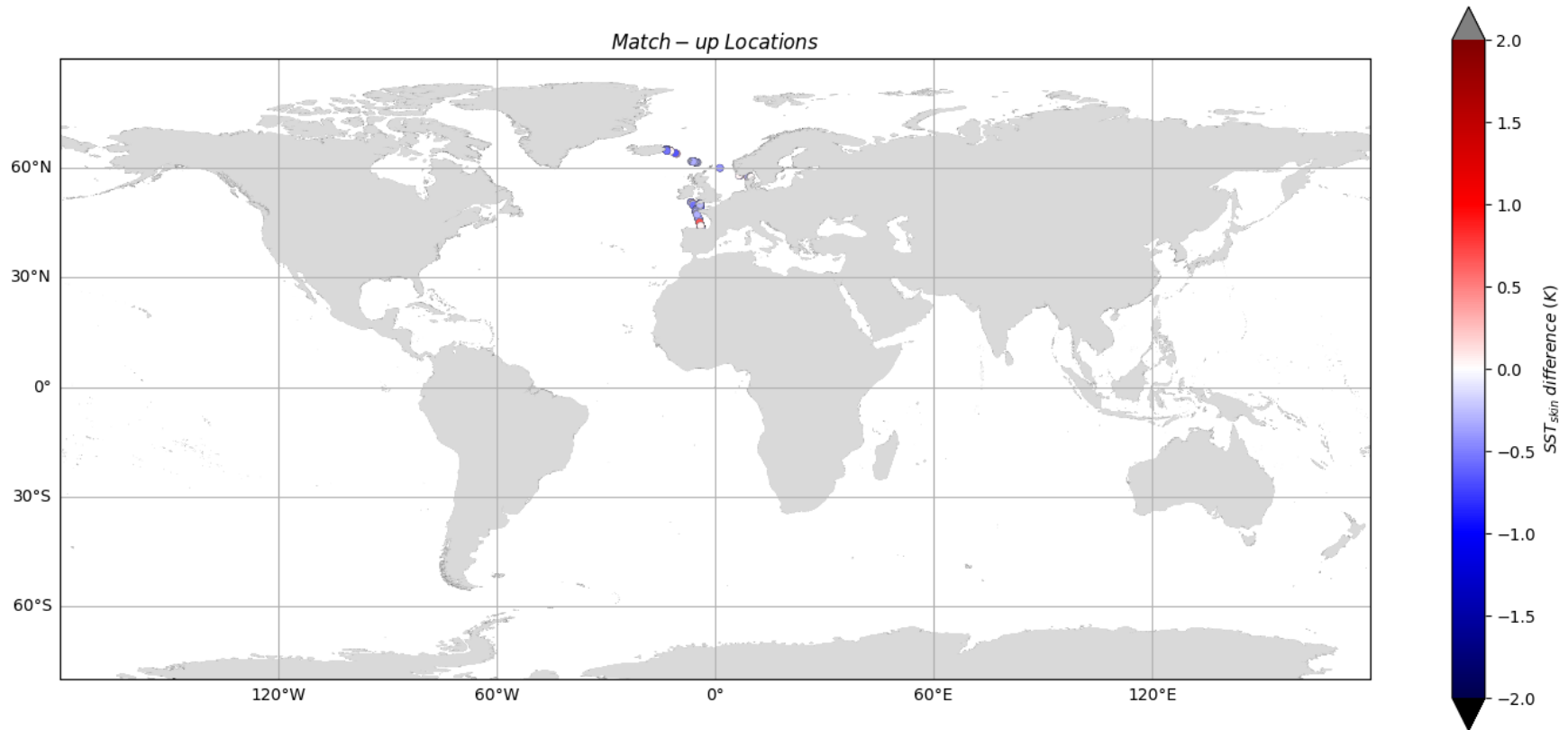


s4sstr1i1, all, sstdiff_sst_wst, grade 2b, all, ghrsst-5, qi-all - HuberT processed 20231117 (c) 2023 ISAR team - v6.1

s4sstr1i1, all, sstdiff_sst_wst, grade 2b, all, ghrsst-5, qi-all - HuberT processed 20231117 (c) 2023 ISAR team - v6.1

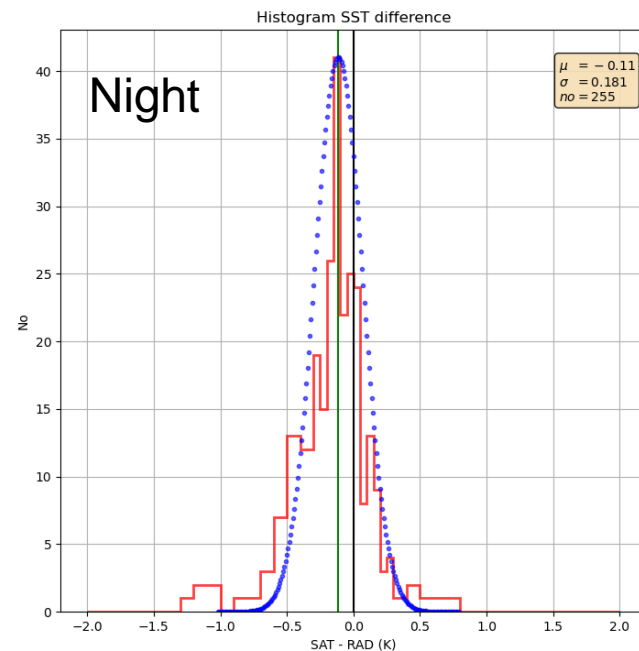
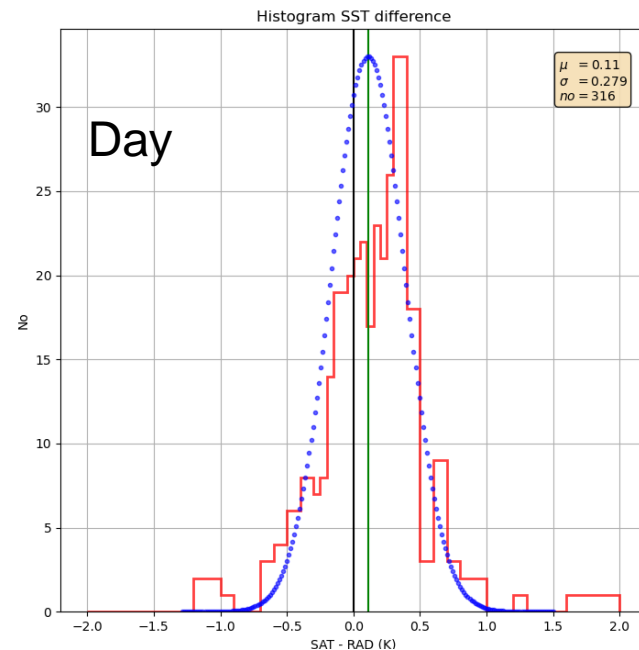
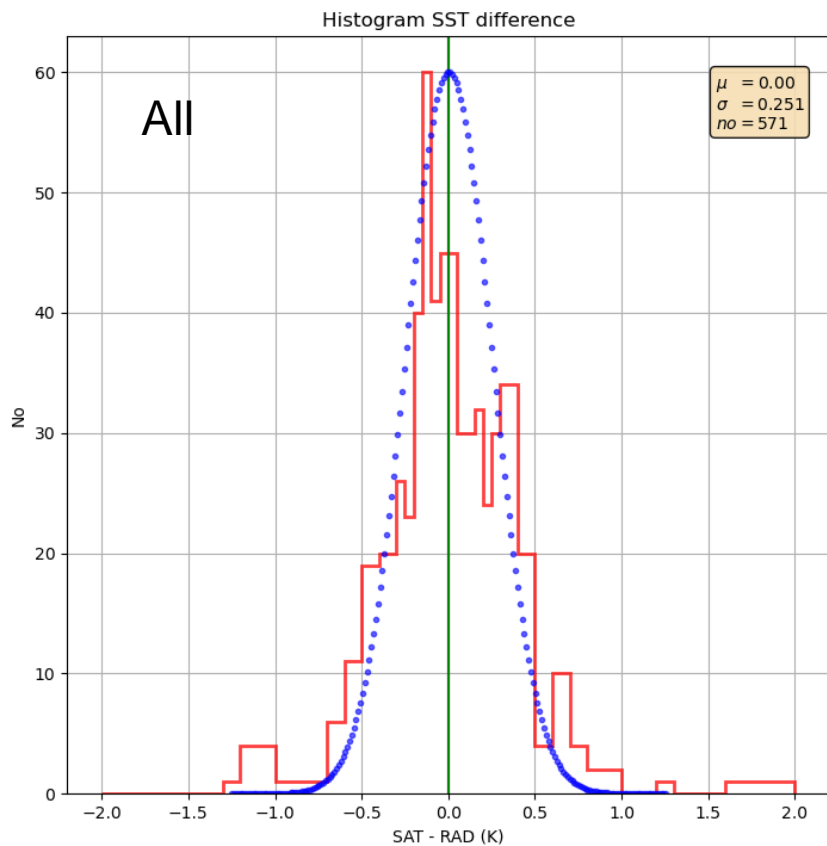
Validation results - global

- WST - 2021, CV5, grade 2b - S3A



Histograms – CV5

2021 – S3A



S3A_2021, wst, grade 2b, all, ghrsst-5, qi-all

processed 20231206 (c) 2023 ISAR team - v2.1

ships4sst

SLSTR validation with ships4sst data

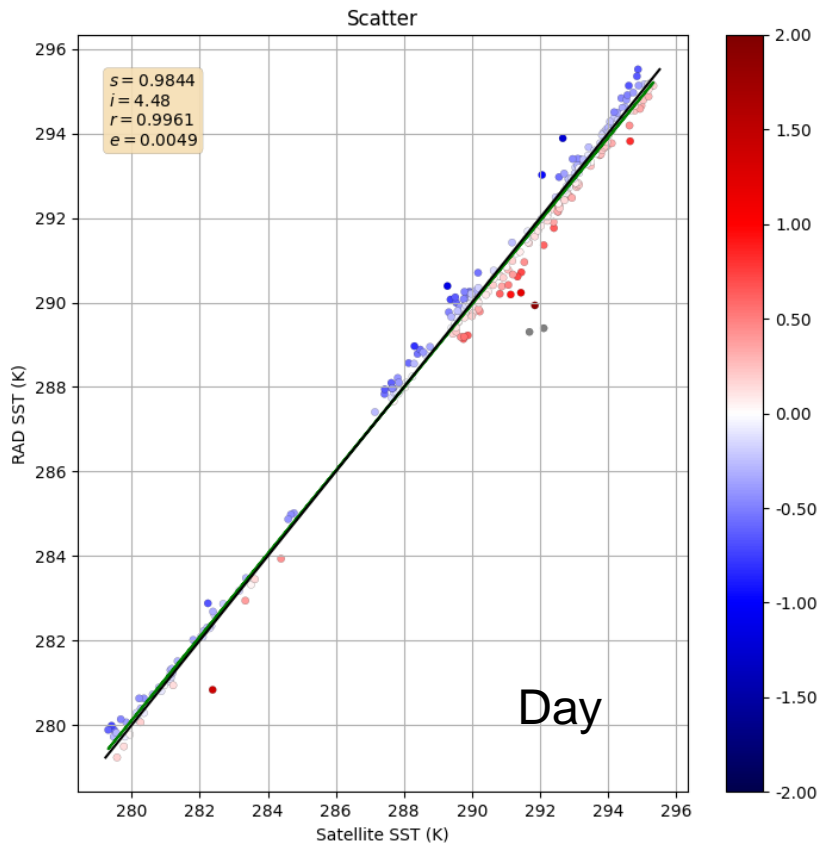


S3A_2021, wst, grade 2b, night, ghrsst-5, qi-all

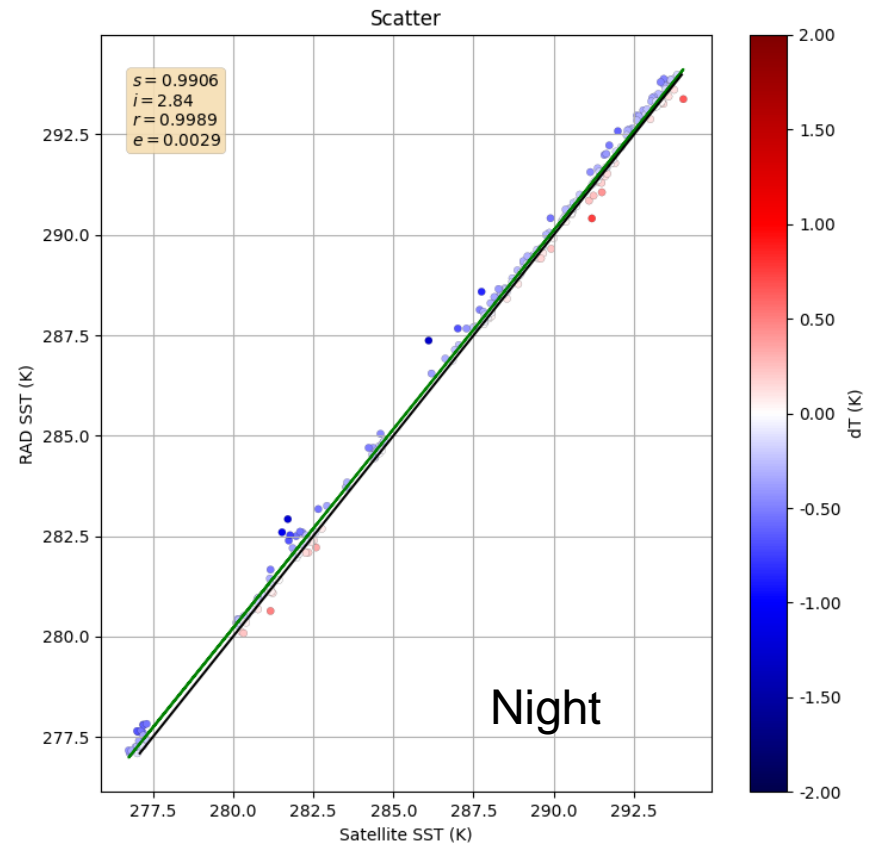
processed 20231206 (c) 2023 ISAR team - v2.1

Validation – scatter, CV 5

2021 - S3A



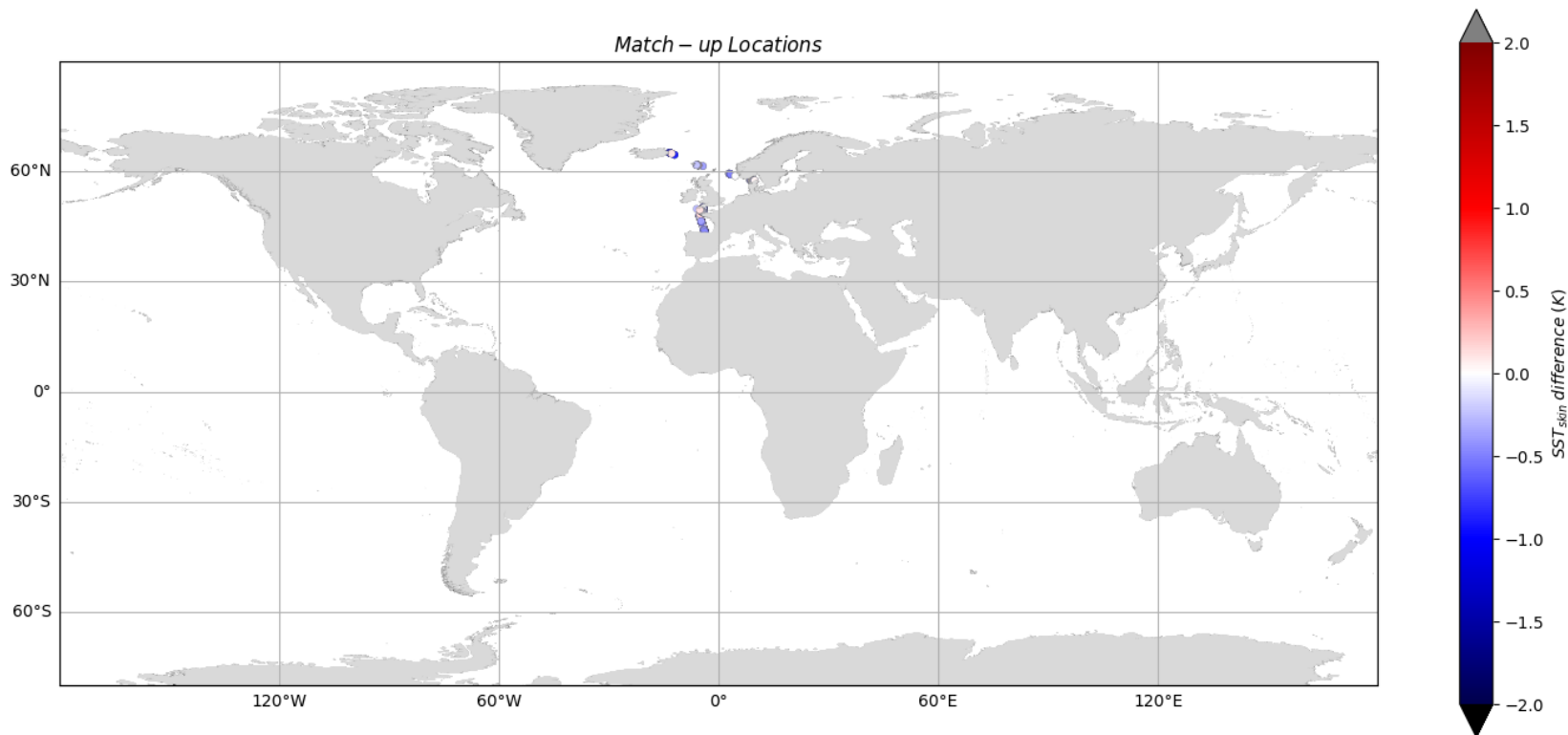
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s4sstr1i1, all, sstdiff_sst_wst, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20231119 (c) 2023 ISAR team - v6.1

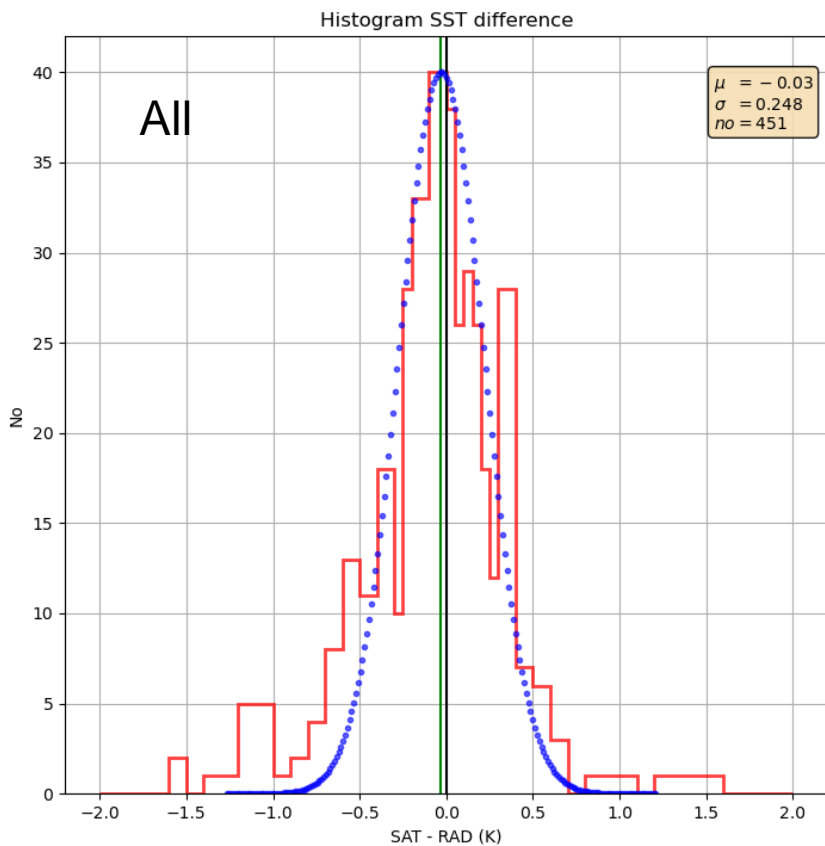
Validation results - global

- WST - 2021, CV5, grade 2b - S3B



Histograms – CV5

2021 - S3B

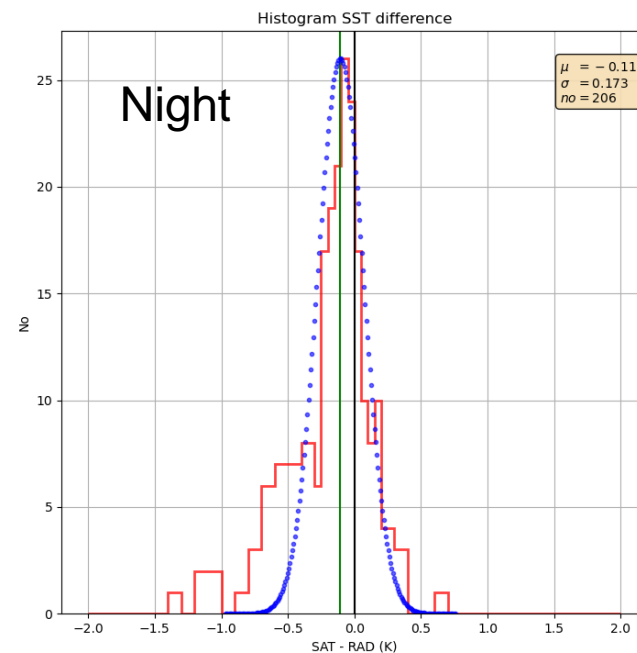
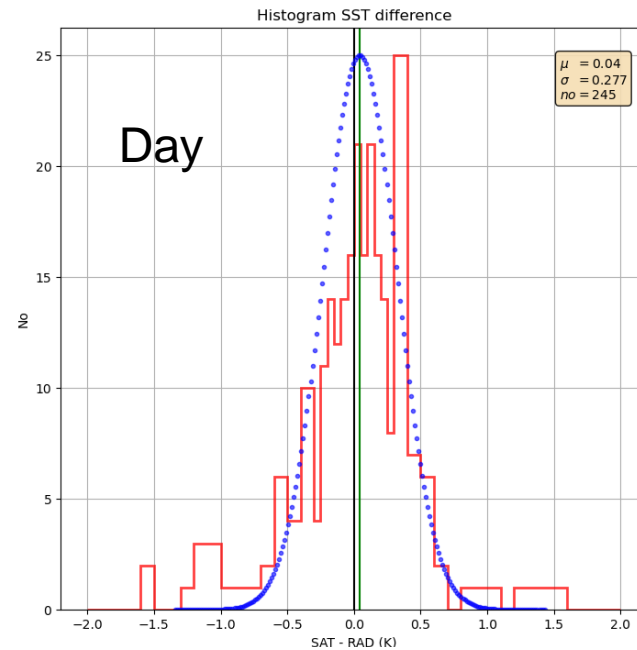


S3B_2021, wst, grade 2b, all, ghrsst-5, qi-all

processed 20231206 (c) 2023 ISAR team - v2.1

ships4sst

SLSTR validation with ships4sst data

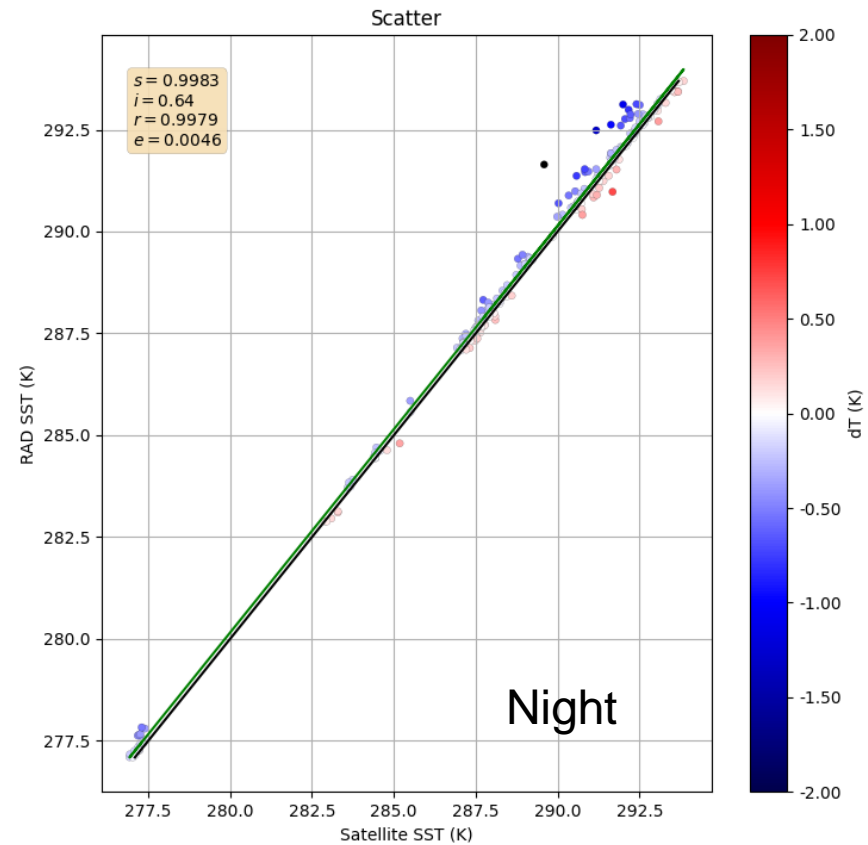
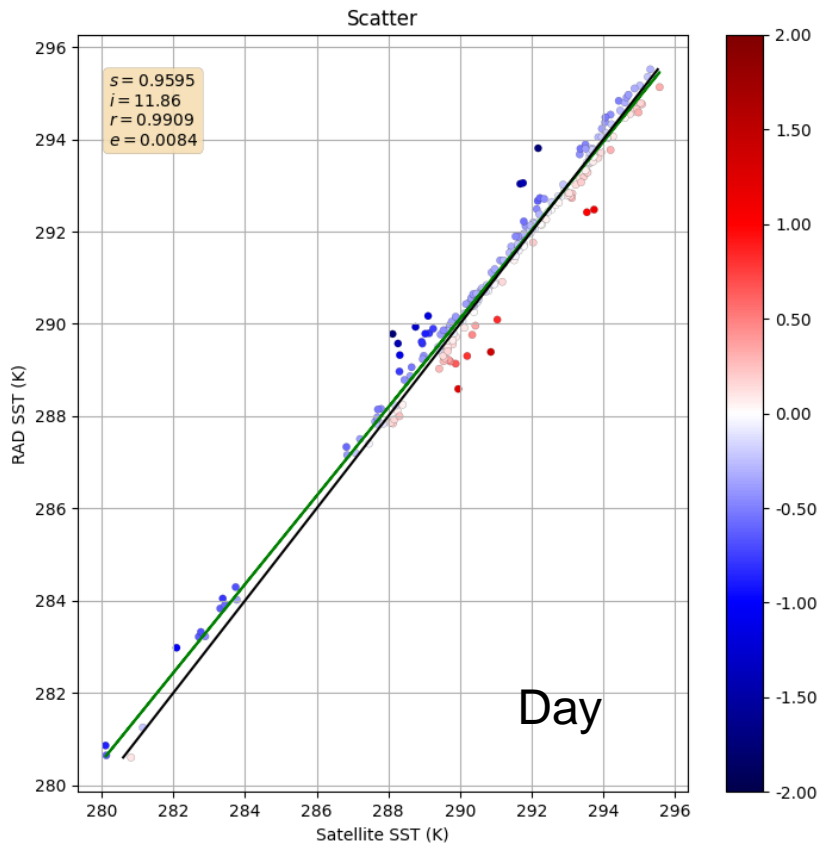


S3B_2021, wst, grade 2b, night, ghrsst-5, qi-all

processed 20231206 (c) 2023 ISAR team - v2.1

Validation – scatter, CV 5

2021 - S3B



s4sstr111, all, sstdiff_sst_wst, grade 2b, day, ghrsst-5, qi-all - HuberT processed 20231120 (c) 2023 ISAR team - v6.1

s4sstr111, all, sstdiff_sst_wst, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20231120 (c) 2023 ISAR team - v6.1

Validation results – statistics

B

- 2021 – S3 A vs B – WST CV5

A

| Day | | | | | | |
|-----------|-------------|-------------|------------|-----------|---------------|---------------|
| Grade | MDif f | RSD | No | Overpass | Min Temp | Max Temp |
| 1 | 0.07 | 0.21 | 87 | 13 | 279.33 | 295.35 |
| 2a | 0.09 | 0.30 | 189 | 24 | 279.25 | 295.43 |
| 2b | 0.11 | 0.28 | 316 | 24 | 279.33 | 295.35 |
| 3 | 0.06 | 0.43 | 729 | 33 | 275.85 | 295.43 |
| 4 | -0.01 | 0.60 | 1979 | 56 | 273.71 | 295.50 |

| Night | | | | | | |
|-----------|--------------|-------------|------------|-----------|---------------|---------------|
| Grade | MDif f | RSD | No | Overpass | Min Temp | Max Temp |
| 1 | -0.08 | 0.18 | 70 | 13 | 276.77 | 293.77 |
| 2a | -0.07 | 0.28 | 140 | 20 | 276.66 | 293.81 |
| 2b | -0.11 | 0.18 | 255 | 18 | 276.77 | 294.06 |
| 3 | -0.05 | 0.30 | 531 | 26 | 276.32 | 294.06 |
| 4 | -0.06 | 0.39 | 1347 | 46 | 276.22 | 294.60 |

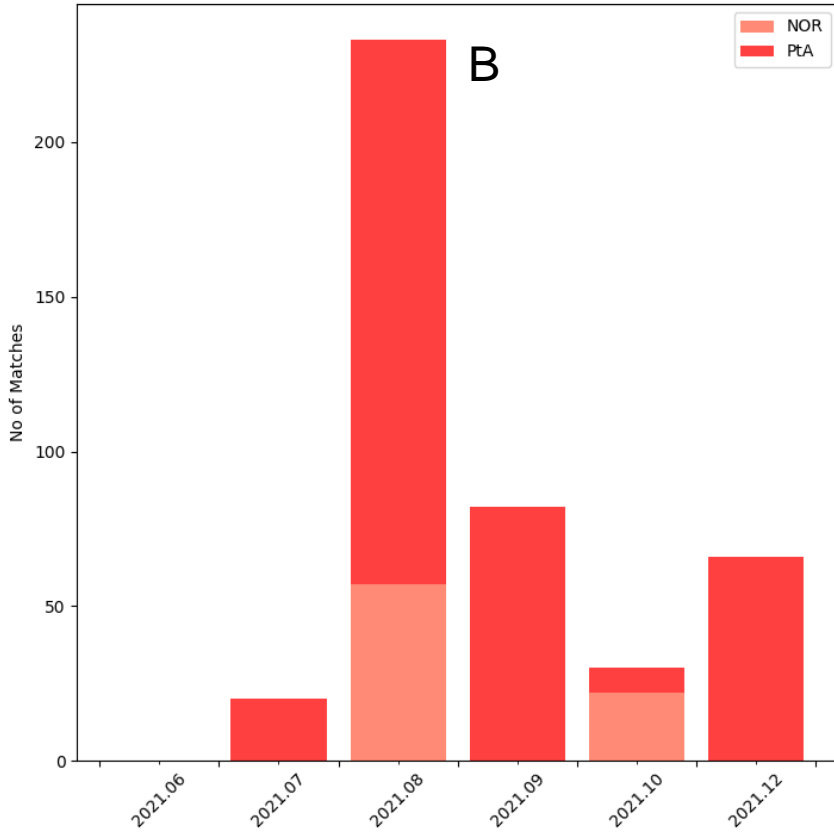
| Day | | | | | | |
|-----------|-------------|-------------|------------|-----------|---------------|---------------|
| Grade | MDif f | RSD | No | Overpass | Min Temp | Max Temp |
| 1 | -0.02 | 0.22 | 82 | 11 | 281.27 | 295.69 |
| 2a | -0.11 | 0.38 | 168 | 25 | 277.12 | 296.05 |
| 2b | 0.04 | 0.28 | 245 | 21 | 280.23 | 295.69 |
| 3 | -0.08 | 0.51 | 592 | 36 | 277.02 | 296.41 |
| 4 | -0.13 | 0.68 | 1685 | 52 | 275.90 | 296.41 |

| Night | | | | | | |
|-----------|--------------|-------------|------------|-----------|---------------|---------------|
| Grade | MDif f | RSD | No | Overpass | Min Temp | Max Temp |
| 1 | -0.10 | 0.14 | 53 | 13 | 277.10 | 293.07 |
| 2a | -0.19 | 0.28 | 116 | 21 | 277.10 | 293.28 |
| 2b | -0.11 | 0.17 | 206 | 20 | 276.92 | 293.84 |
| 3 | -0.17 | 0.37 | 484 | 26 | 276.92 | 294.14 |
| 4 | -0.22 | 0.42 | 1266 | 48 | 274.33 | 294.68 |

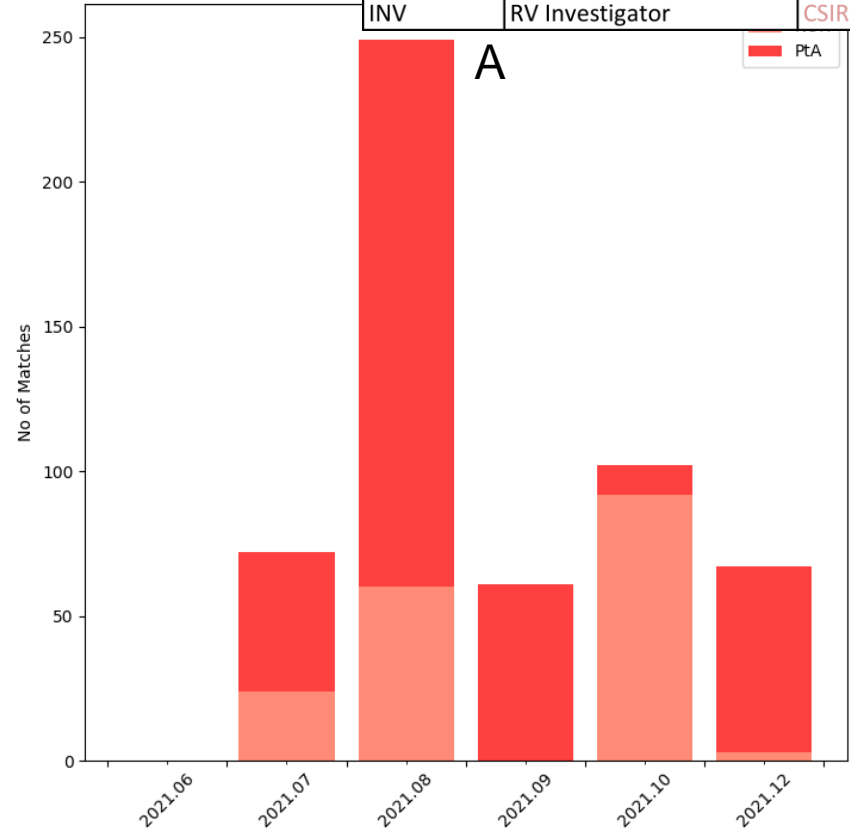
Validation results – RDAC split

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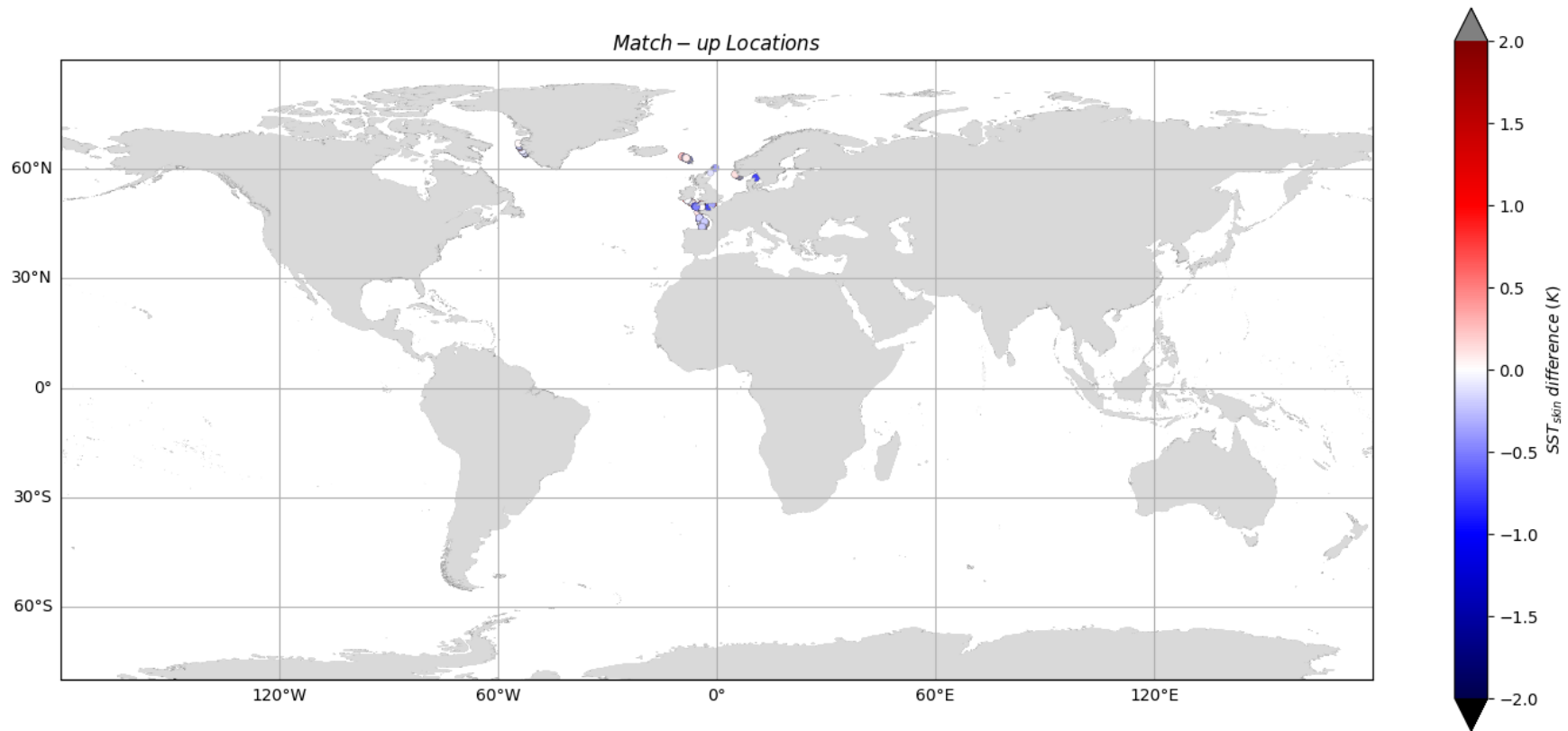
s4sstr111, all, sstdiff_sst_wst, grade 2b, all, ghrsst-5, qi-all - HuberT processed 20231120 (c) 2023 ISAR team - v6.1



s4sstr111, all, sstdiff_sst_wst, grade 2b, all, ghrsst-5, qi-all - HuberT processed 20231119 (c) 2023 ISAR team - v6.1

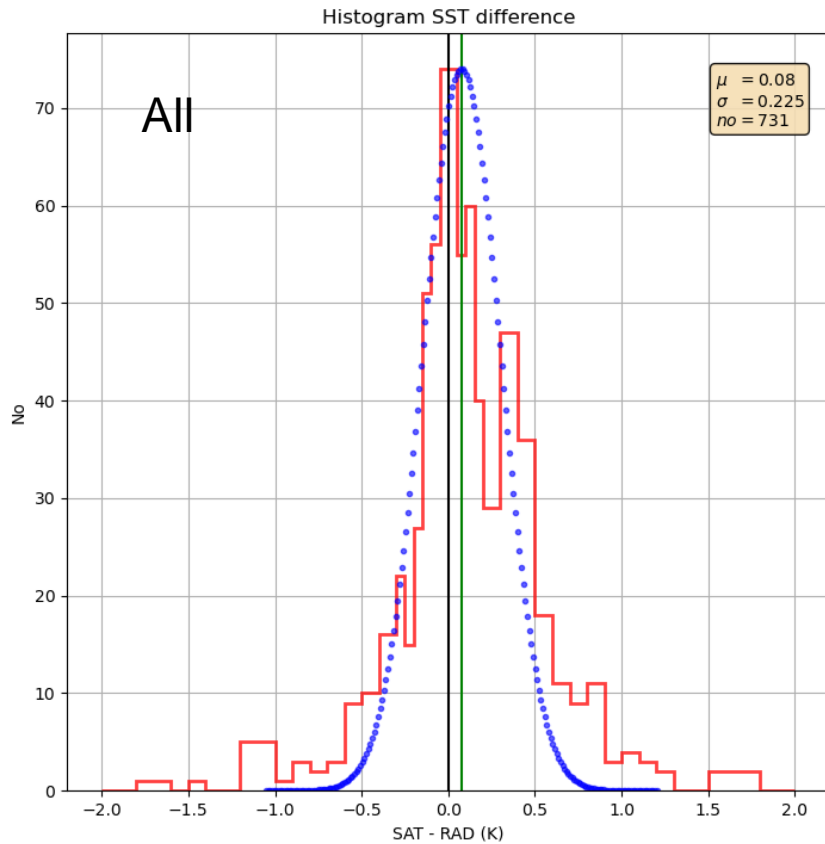
Validation results - global

- WST - 2022, CV5, grade 2b - S3A



Histograms – CV5

2022 – S3A

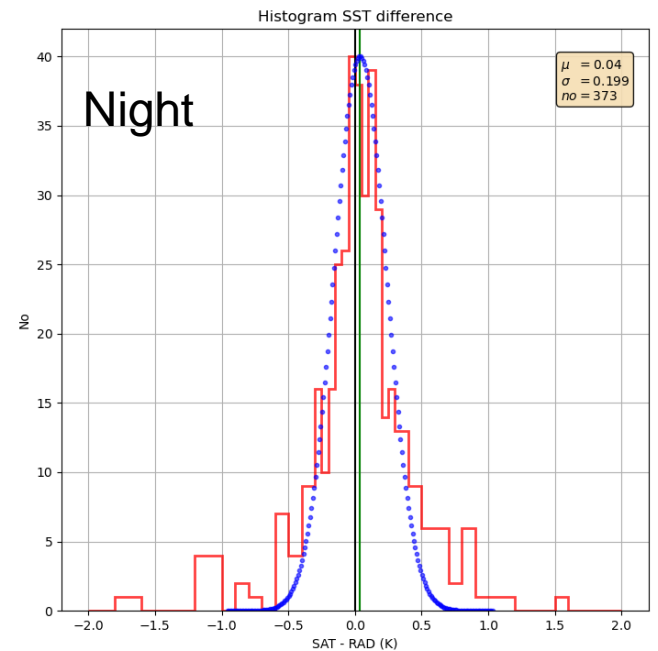
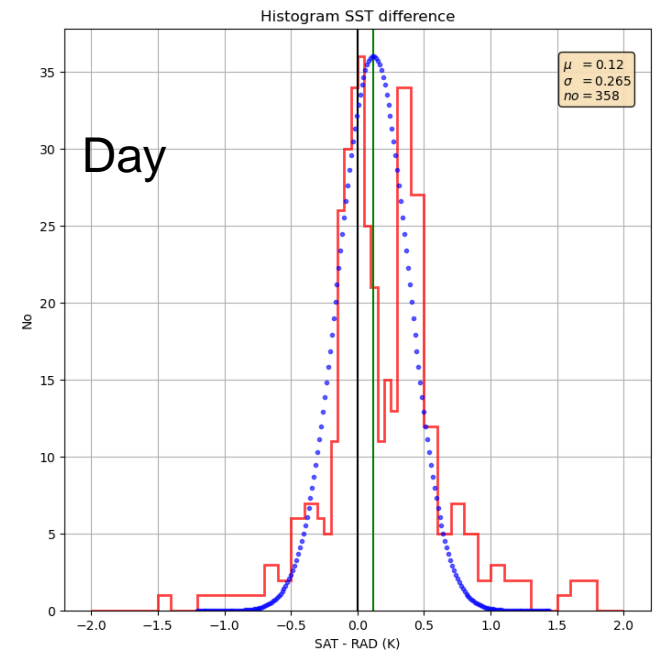


S3A_2022, wst, grade 2b, all, ghrsst-5, qi-all

processed 20231206 (c) 2023 ISAR team - v2.1

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SLSTR validation with ships4sst data

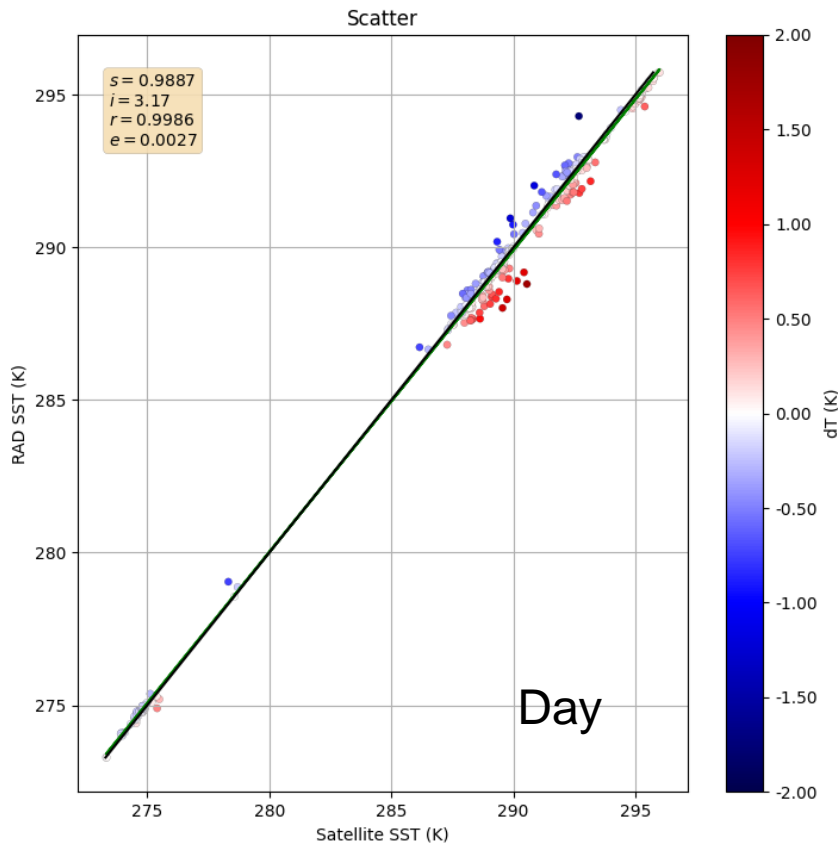


S3A_2022, wst, grade 2b, night, ghrsst-5, qi-all

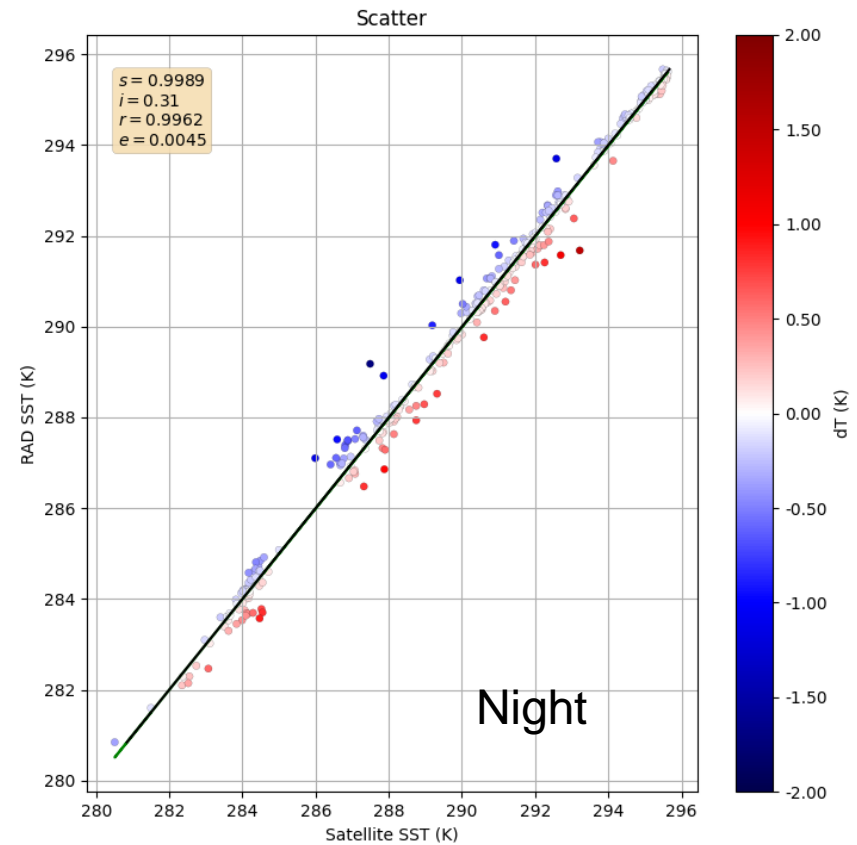
processed 20231206 (c) 2023 ISAR team - v2.1

Validation – scatter, CV 5

2022 - S3A



s4sstr1i1, all, sstdiff_sst_wst, grade 2b, day, ghrsst-5, qi-all - HuberT processed 20231120 (c) 2023 ISAR team - v6.1

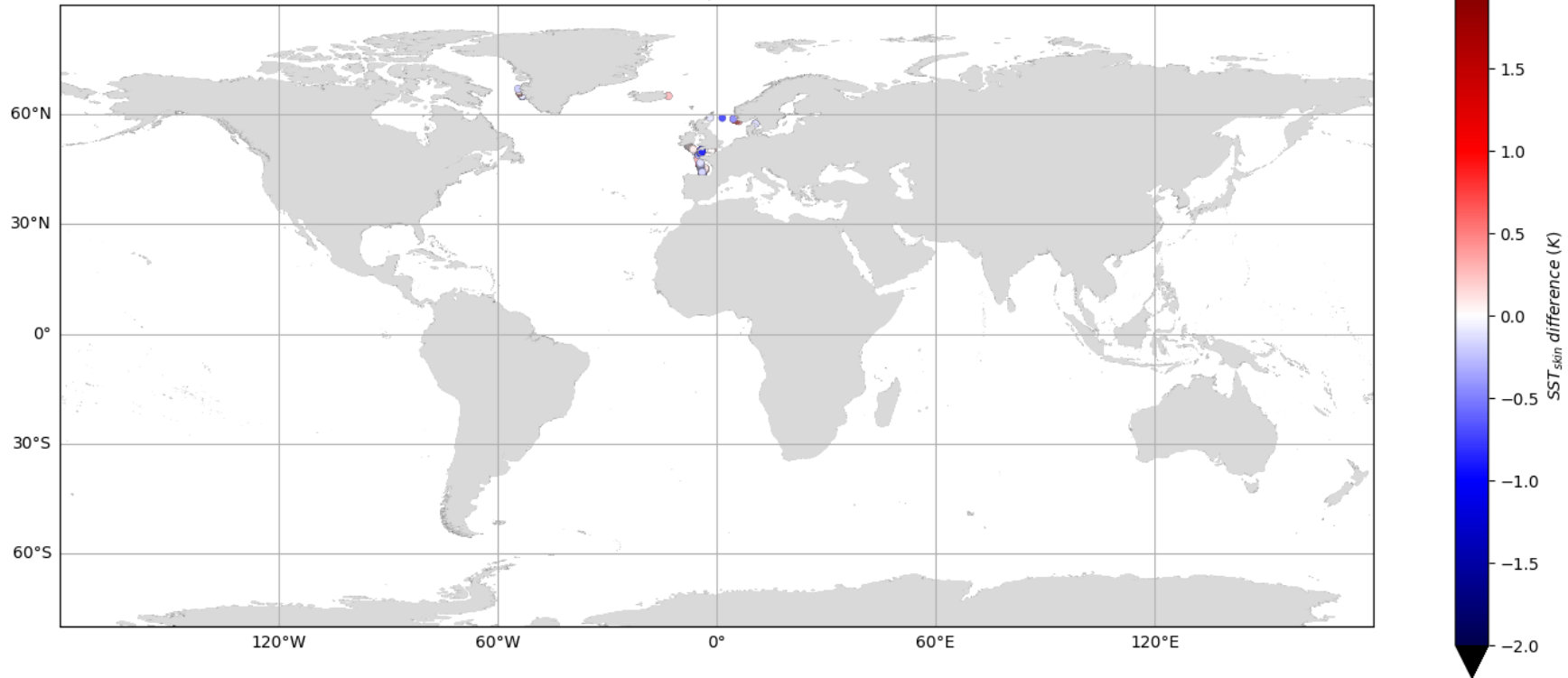


s4sstr1i1, all, sstdiff_sst_wst, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20231120 (c) 2023 ISAR team - v6.1

Validation results - global

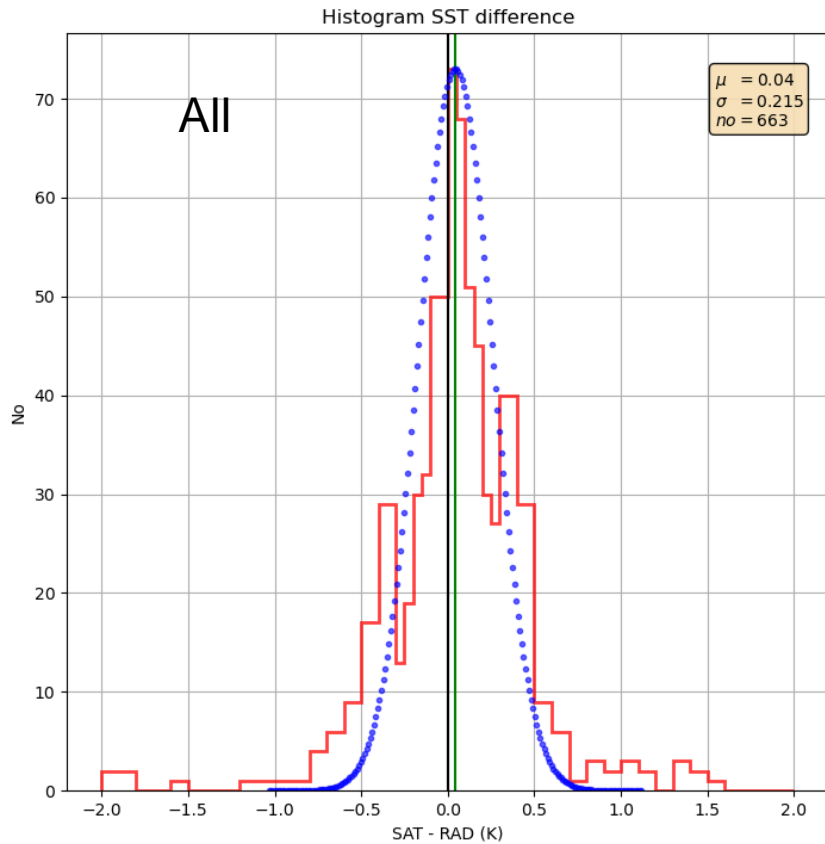
- WST - 2022, CV5, grade 2b - S3B

Match – up Locations



Histograms – CV5

2022 - S3B

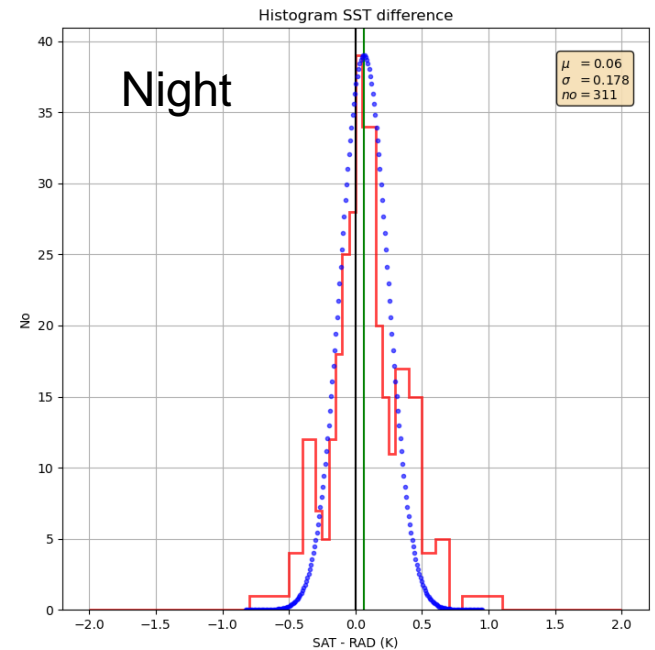
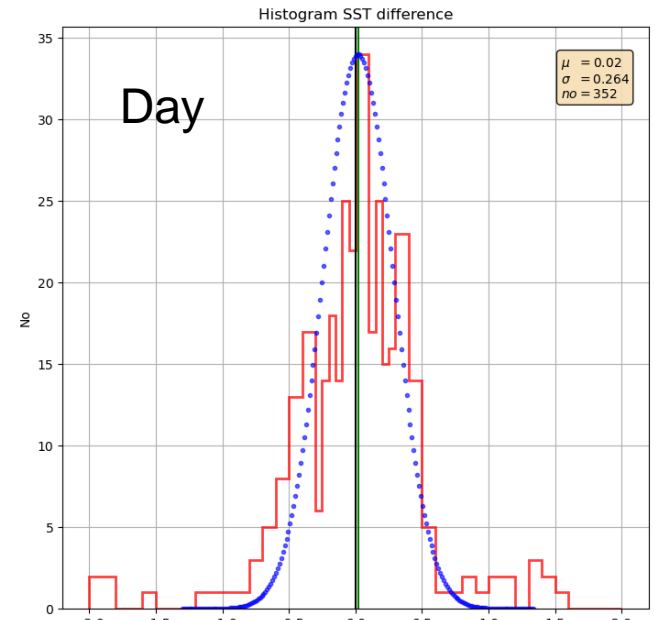


S3B_2022, wst, grade 2b, all, ghrsst-5, qi-all

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SLSTR validation with ships4sst data

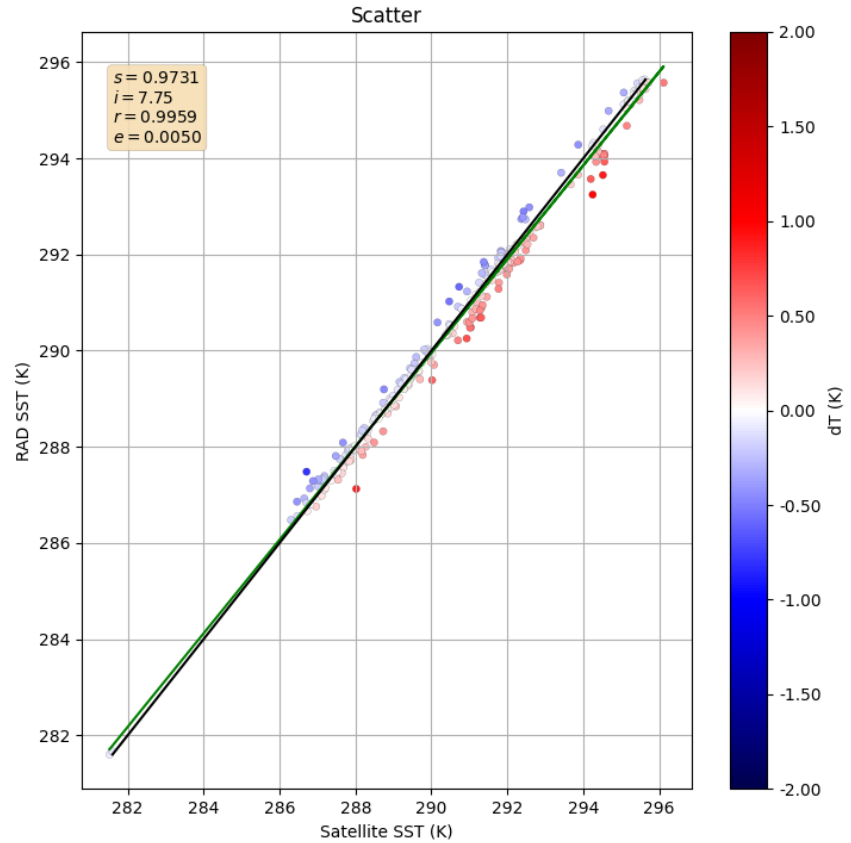
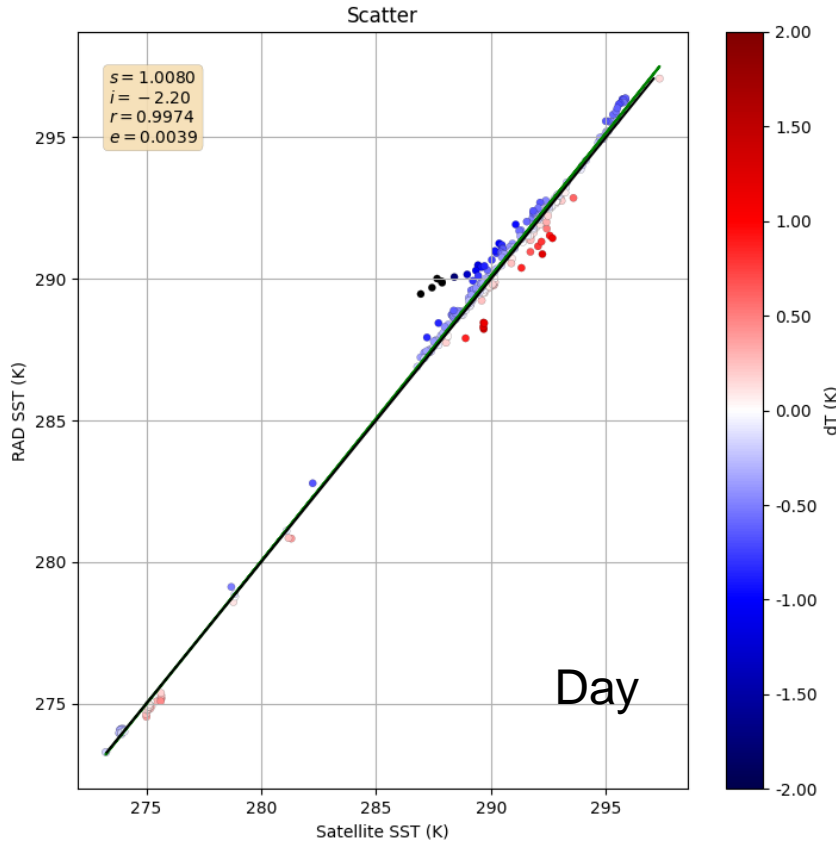


S3B_2022, wst, grade 2b, night, ghrsst-5, qi-all

processed 20231206 (c) 2023 ISAR team - v2.1

Validation – scatter, CV 5

2022 - S3B



s4sstr1i1, all, sstdiff_sst_wst, grade 2b, day, ghrsst-5, qi-all - HuberT processed 20231121 (c) 2023 ISAR team - v6.1

s4sstr1i1, all, sstdiff_sst_wst, grade 2b, night, ghrsst-5, qi-all - HuberT processed 20231121 (c) 2023 ISAR team - v6.1

Validation results – statistics

B

- 2022 – S3 A vs B

A

| Day | | | | | | |
|-----------|-------------|-------------|------------|-----------|---------------|---------------|
| Grade | MDif f | RSD | No | Overpass | Min Temp | Max Temp |
| 1 | 0.06 | 0.18 | 108 | 19 | 273.96 | 296.09 |
| 2a | 0.06 | 0.36 | 286 | 43 | 273.95 | 296.09 |
| 2b | 0.12 | 0.26 | 358 | 33 | 273.33 | 296.15 |
| 3 | 0.11 | 0.51 | 1051 | 61 | 273.21 | 299.04 |
| 4 | 0.04 | 0.59 | 3056 | 93 | 273.21 | 299.04 |

| Day | | | | | | |
|-----------|-------------|-------------|------------|-----------|---------------|---------------|
| Grade | MDif f | RSD | No | Overpass | Min Temp | Max Temp |
| 1 | -0.04 | 0.19 | 96 | 16 | 273.35 | 295.94 |
| 2a | -0.05 | 0.52 | 255 | 41 | 273.35 | 295.94 |
| 2b | 0.02 | 0.26 | 352 | 29 | 273.35 | 297.45 |
| 3 | 0.02 | 0.58 | 970 | 51 | 273.35 | 298.00 |
| 4 | 0.04 | 0.68 | 2805 | 81 | 273.35 | 298.00 |

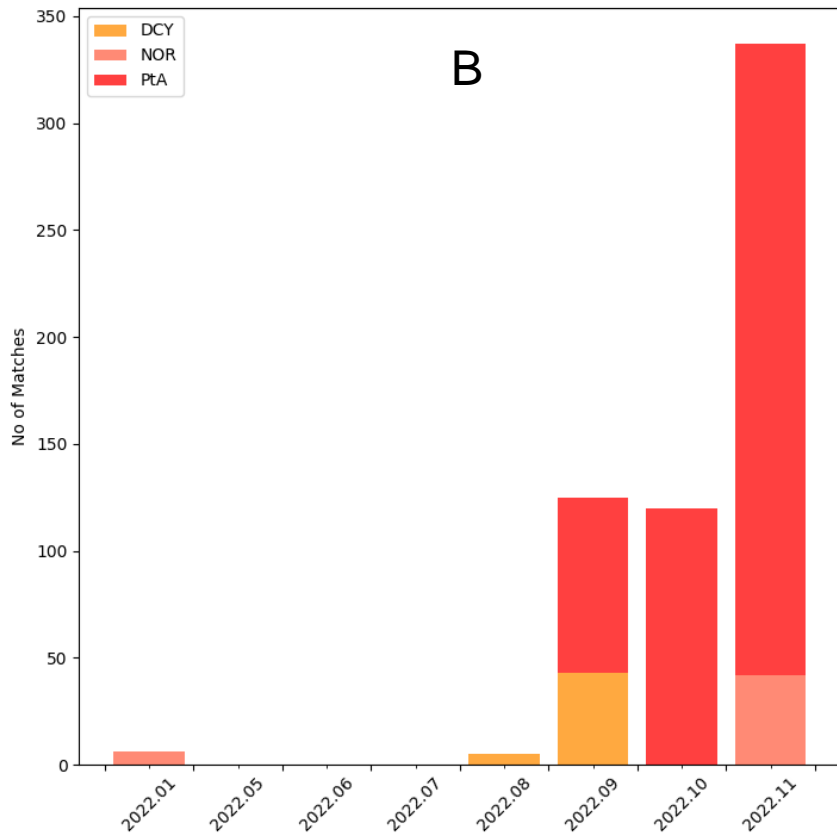
| Night | | | | | | |
|-----------|-------------|-------------|------------|-----------|---------------|---------------|
| Grade | MDif f | RSD | No | Overpass | Min Temp | Max Temp |
| 1 | 0.10 | 0.20 | 86 | 13 | 281.51 | 295.72 |
| 2a | 0.08 | 0.32 | 156 | 24 | 273.15 | 295.72 |
| 2b | 0.06 | 0.18 | 311 | 18 | 281.51 | 296.14 |
| 3 | 0.08 | 0.32 | 655 | 36 | 273.15 | 296.14 |
| 4 | 0.05 | 0.37 | 1813 | 83 | 273.15 | 296.32 |

| Night | | | | | | |
|-----------|-------------|-------------|------------|-----------|---------------|---------------|
| Grade | MDif f | RSD | No | Overpass | Min Temp | Max Temp |
| 1 | 0.03 | 0.18 | 115 | 19 | 281.52 | 295.67 |
| 2a | 0.04 | 0.25 | 202 | 28 | 276.22 | 295.67 |
| 2b | 0.04 | 0.20 | 373 | 24 | 280.55 | 295.67 |
| 3 | -0.03 | 0.31 | 714 | 34 | 275.29 | 295.67 |
| 4 | -0.07 | 0.48 | 1860 | 70 | 275.06 | 297.82 |

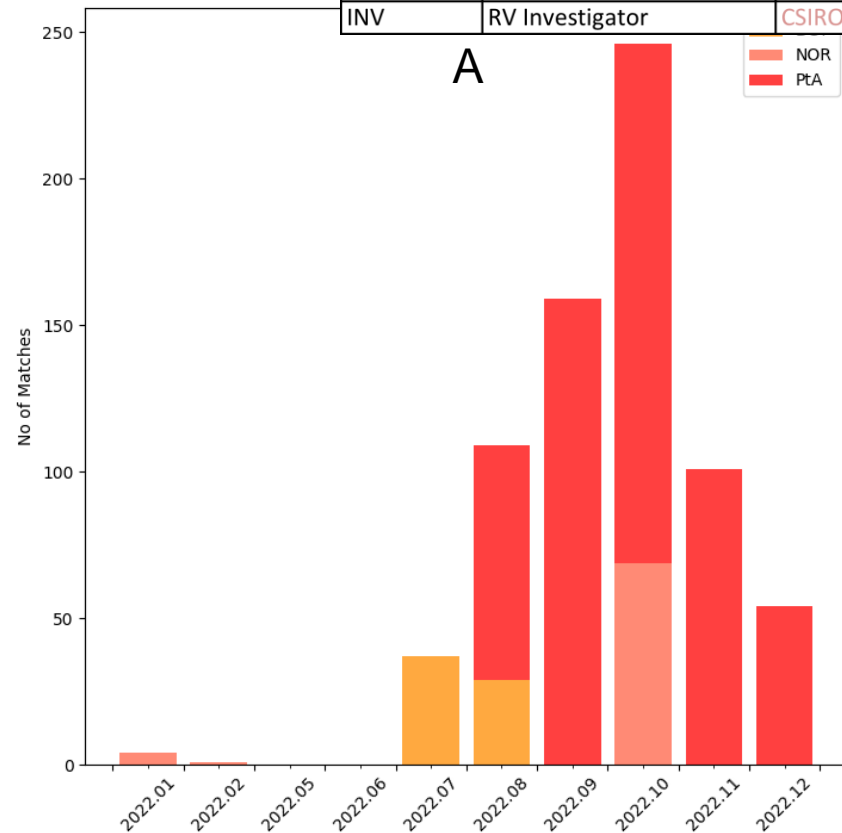
Validation results – RDAC split

■ 2022

| 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 |



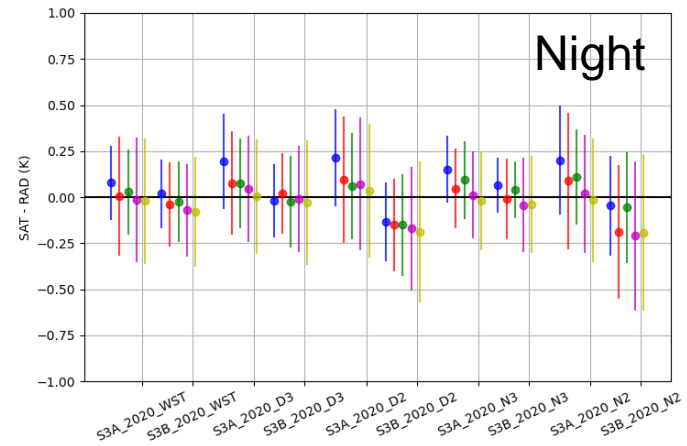
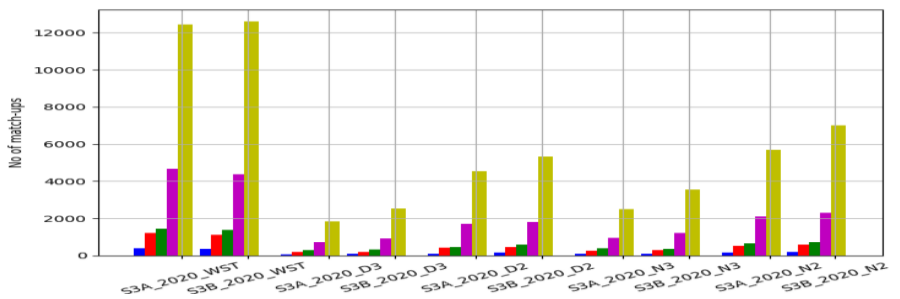
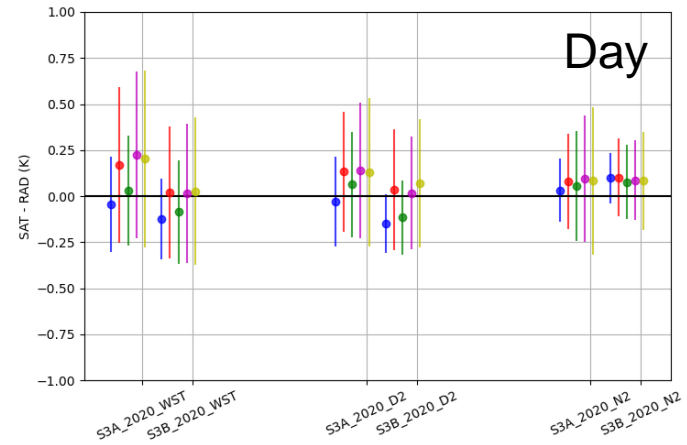
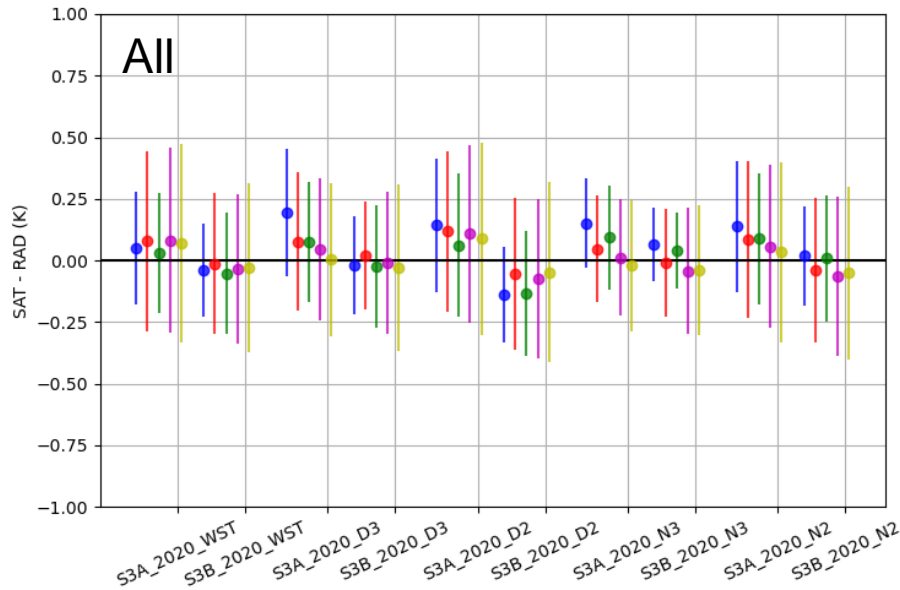
s4sstr111, all, sstdiff_sst_wst, grade 2b, all, ghrsst-5, qi-all - HuberT processed 20231121 (c) 2023 ISAR team - v6.1



s4sstr111, all, sstdiff_sst_wst, grade 2b, all, ghrsst-5, qi-all - HuberT processed 20231120 (c) 2023 ISAR team - v6.1

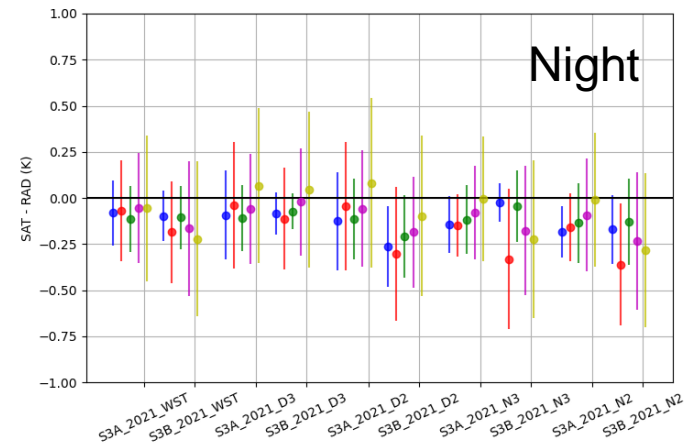
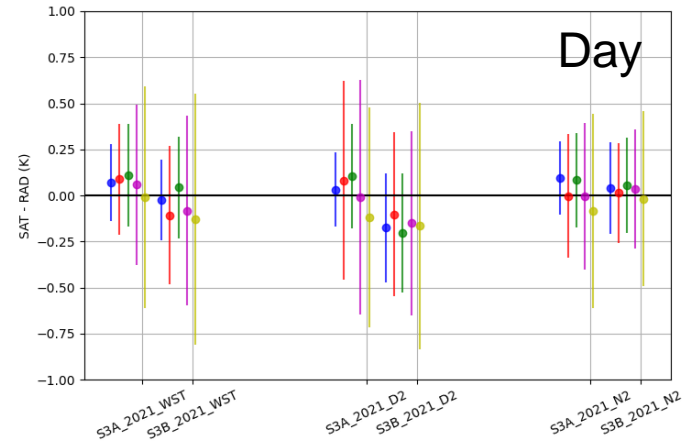
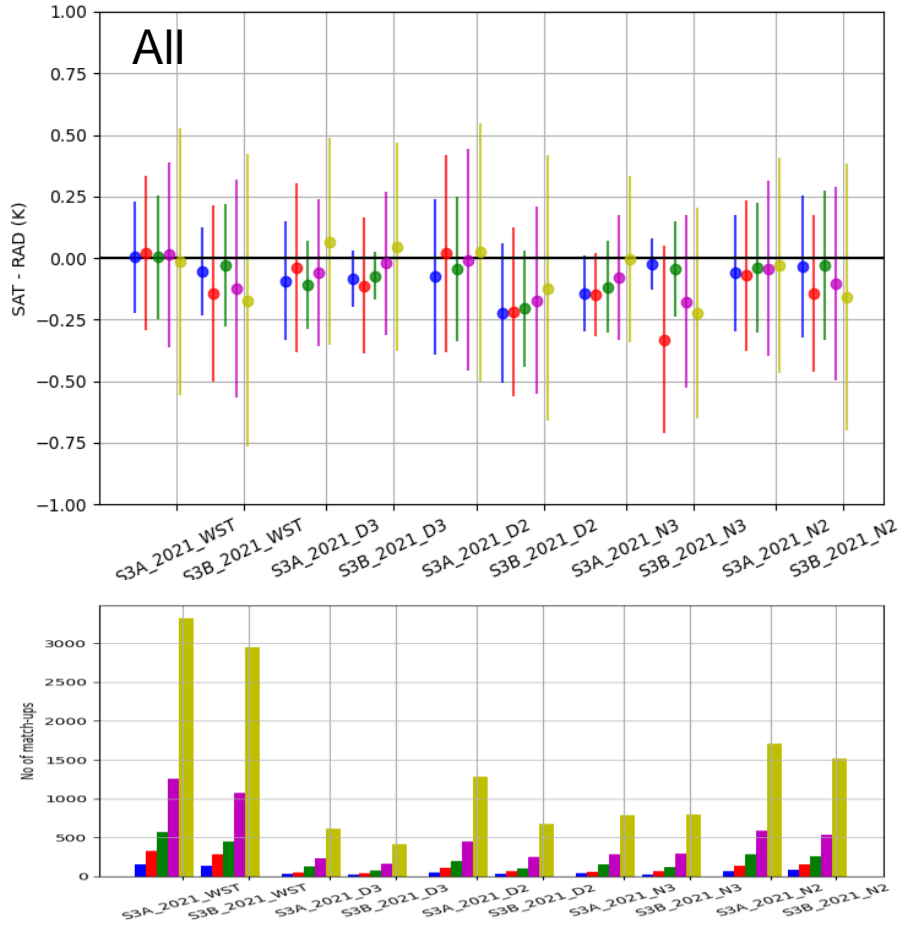
Validation results – D3,D2,N3,N2 - all

- 2020 - CV5, D3, N3 excluded in day time



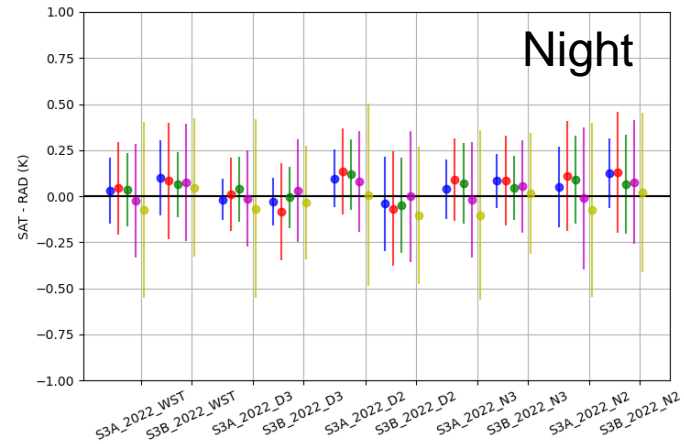
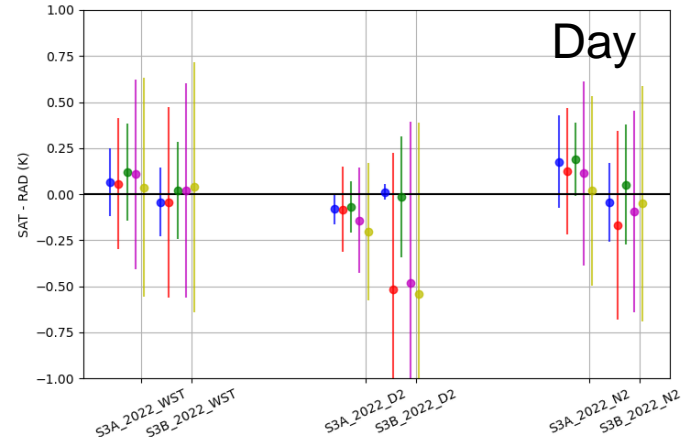
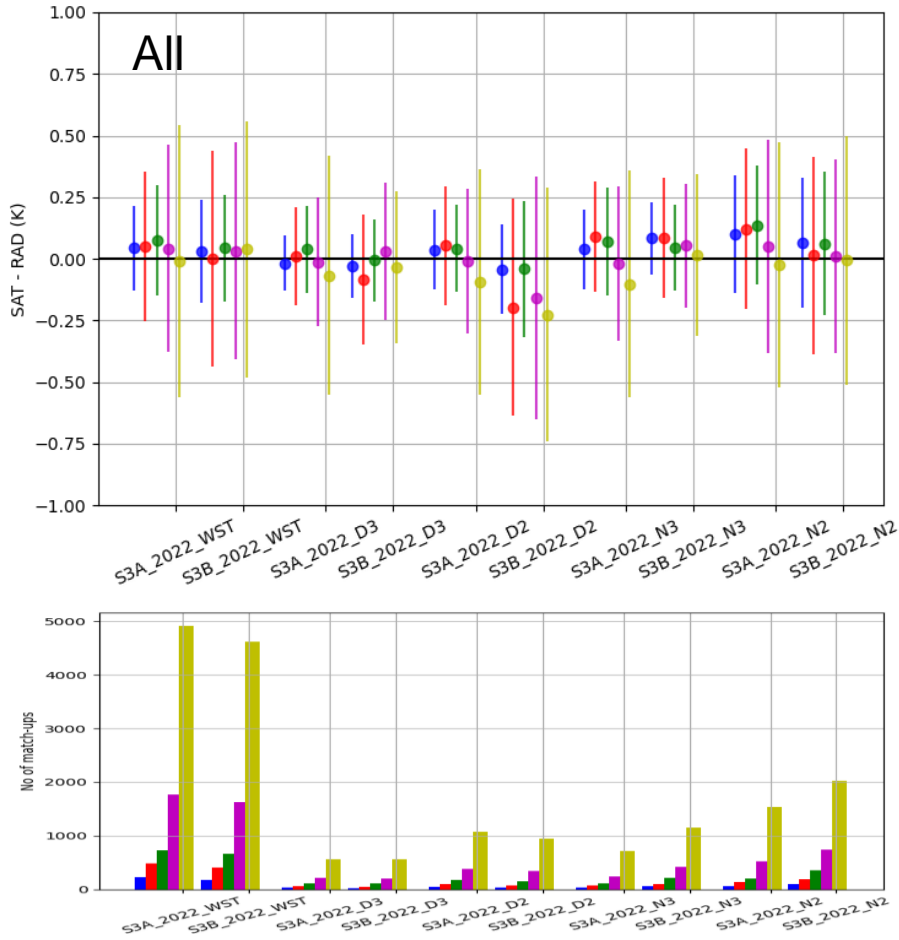
Validation results – D3,D2,N3,N2 - all

- 2021 - CV5, D3, N3 excluded in day time



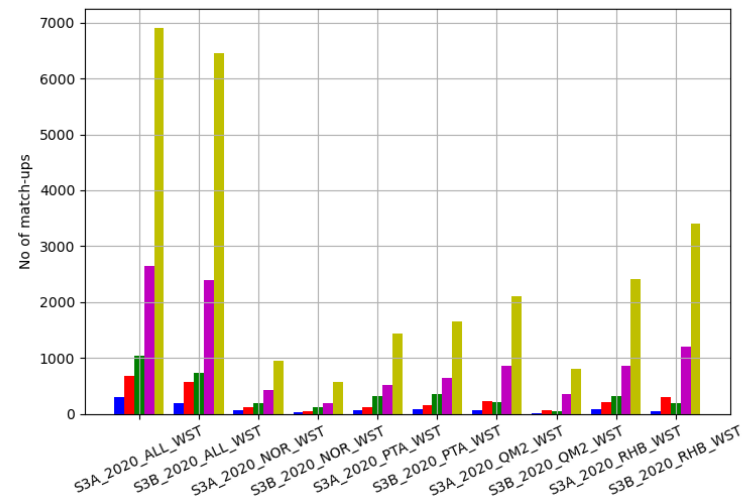
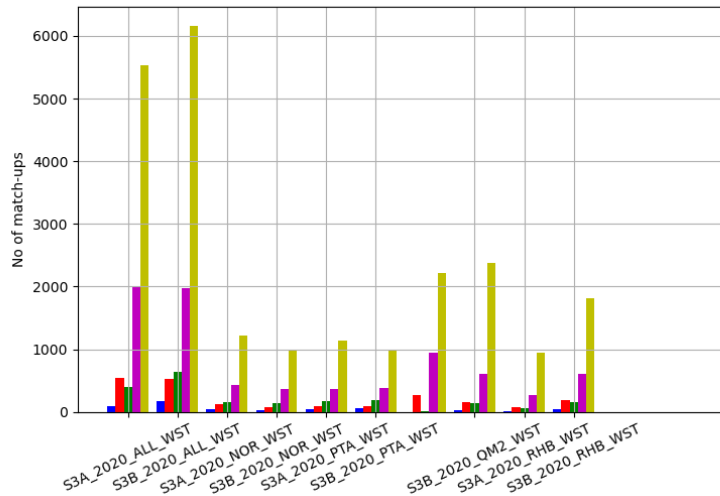
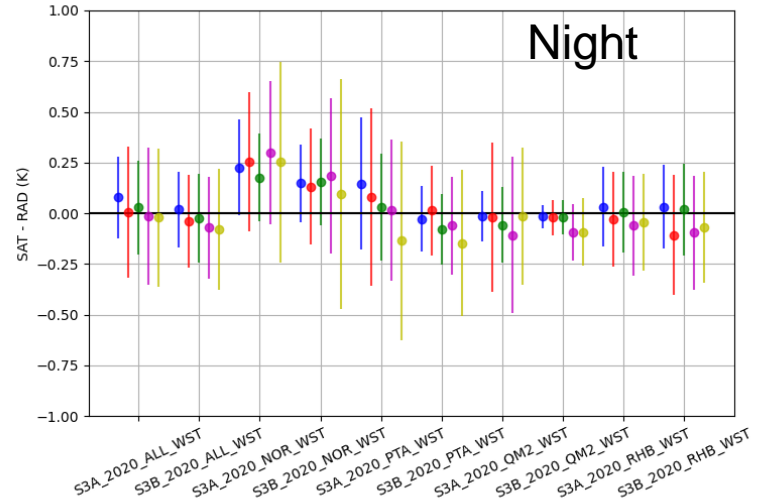
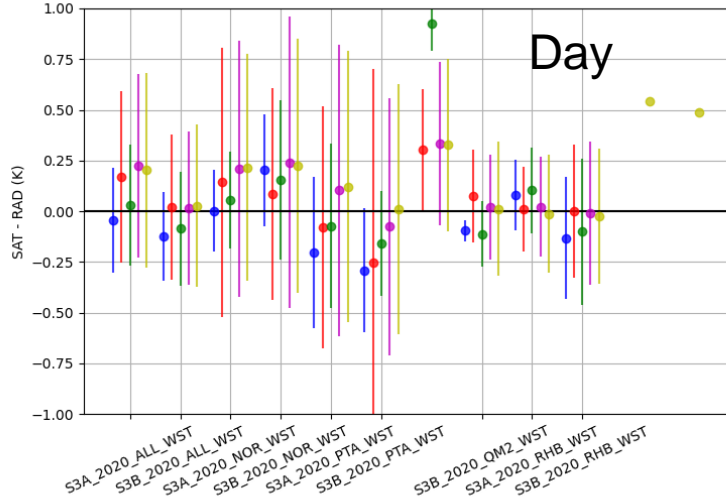
Validation results – D3,D2,N3,N2 - all

- 2022 - CV5, D3, N3 excluded in day time



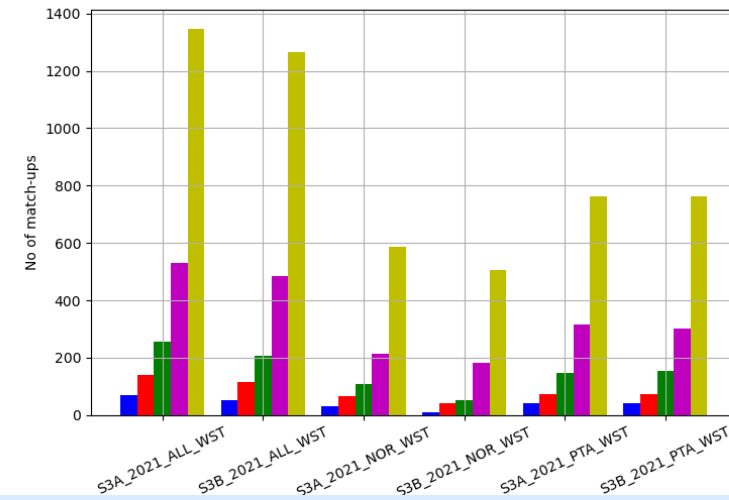
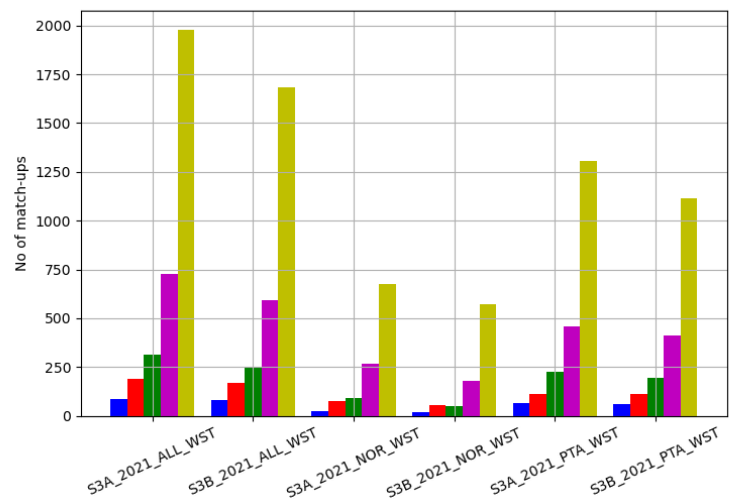
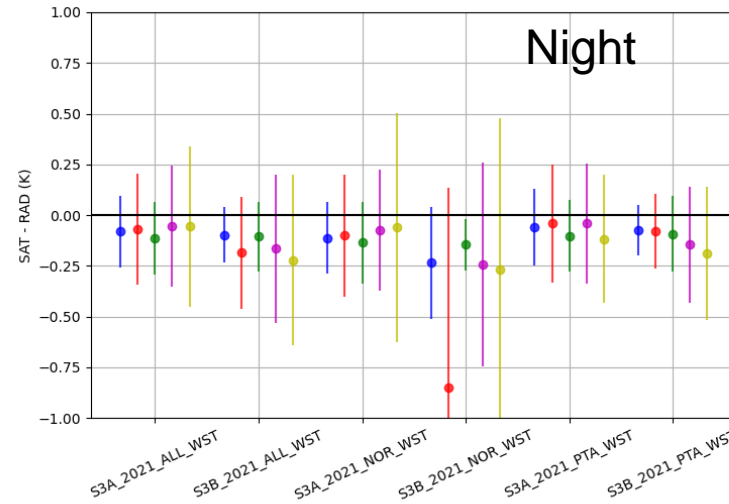
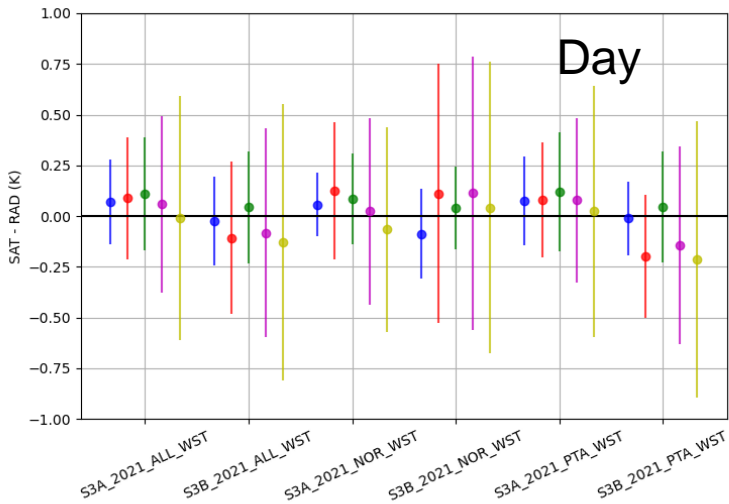
Validation results – Regional

- 2020 – WST CV5



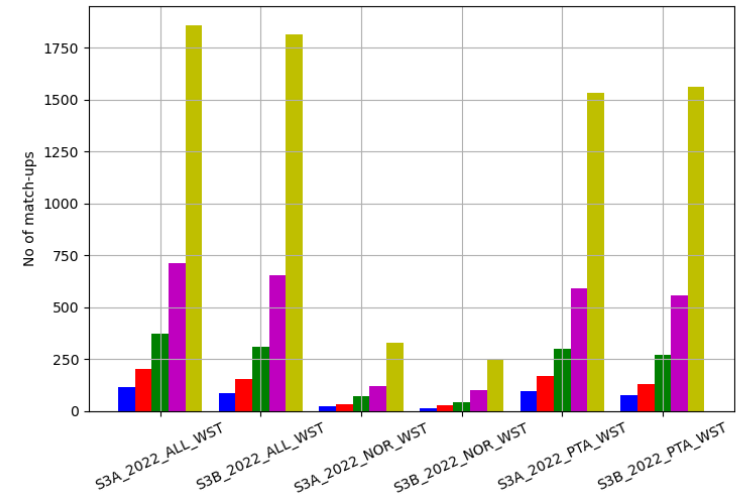
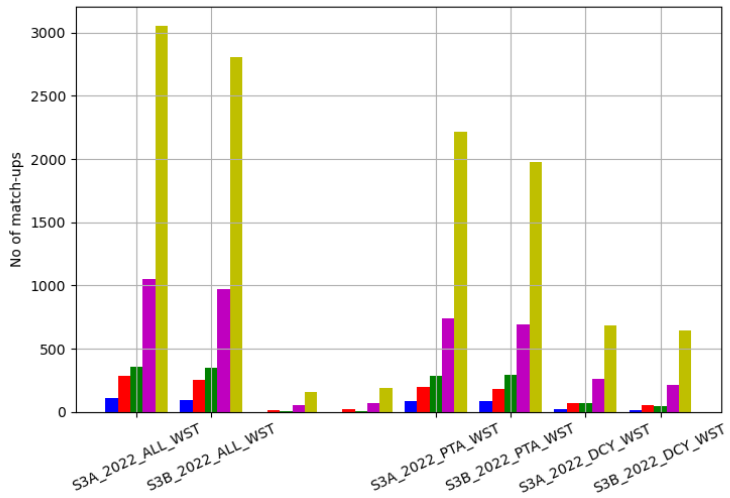
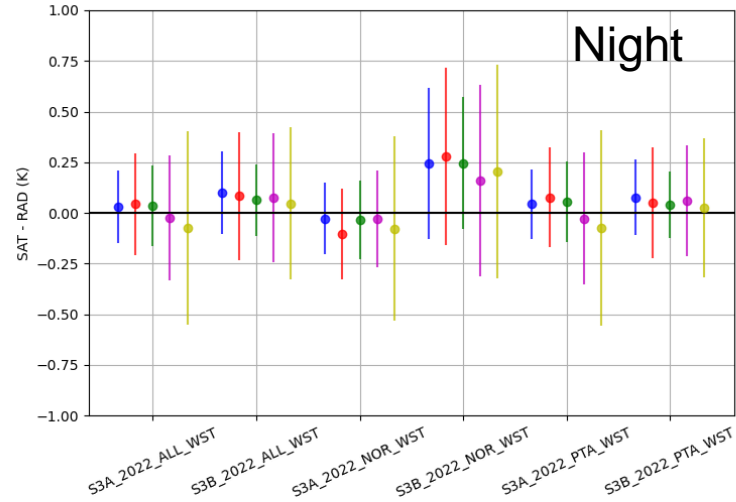
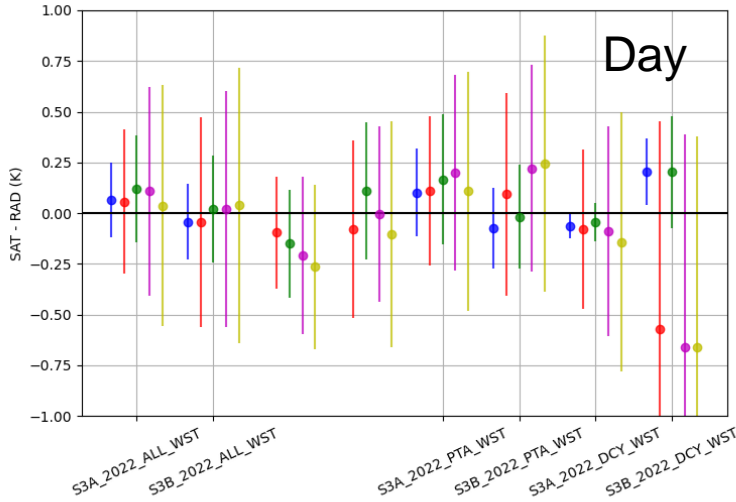
Validation results – Regional

- 2021 – WST CV5



Validation results – Regional

- 2022 – WST CV5



Summary

- 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 .
 - Some mean differences, mainly SLSTR 3 B D2 data in 2020 and 2021
 - RSD is lower at night than day time and comparable to AATSR .
 - Some regional differences
 - Lower data volume in 2021 and 2022, due to slow COVID recovery of some shipping operators
- Validation data
 - Felyx processing at EUMETSAT
 - WST and WCT data for 2018, 2019 is available
 - **2020-2022 data**