Water Surface Temperature intercomparisons at Wraysbury reservoir and in the North Atlantic

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WST intercomparisons

- Level 2 intercomparison of WSTs derived from observed radiances
  – Extends the laboratory intercomparison exercise to include WST models and real environmental signals
- Two intercomparison campaigns
  – Ten instruments deployed on moored platform in Wraysbury reservoir
  – Two instruments (SISTeR and ISAR) deployed on *Queen Mary 2* liner

Wraysbury reservoir

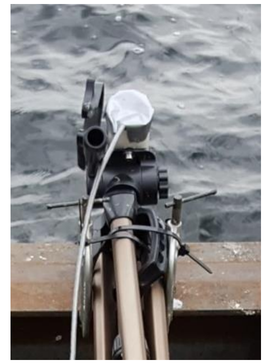
- Intercomparison held on NPL moored platform in Wraysbury reservoir, just west of Heathrow airport
- Five days of measurements from 27/06/2016 to 01/07/2016
- Mixed weather – sun, cloud, occasional showers
- Nine participating institutions and ten instruments
- Measurements collected “blind” for analysis by NPL
- See FRM4STS document “*2016 comparison of IR brightness temperature measurements in support of satellite validation. Part 3: Water surface temperature comparison of radiation thermometers*” (NPL Report ENV 15) for more detail.

Wraysbury reservoir

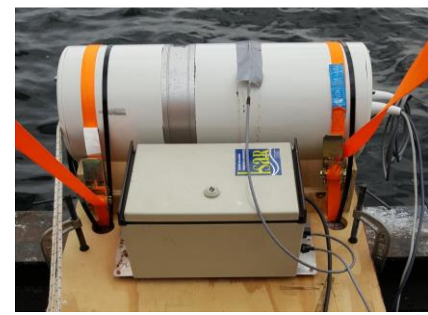
Wraysbury participants

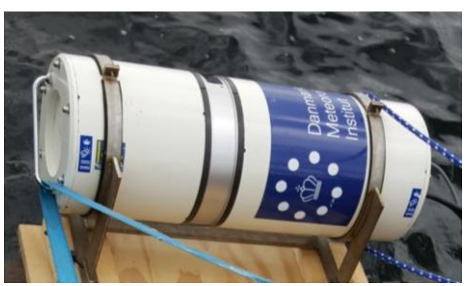
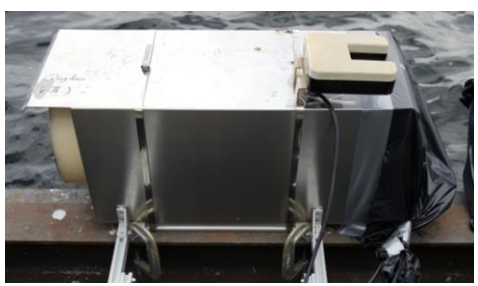
RAL Space

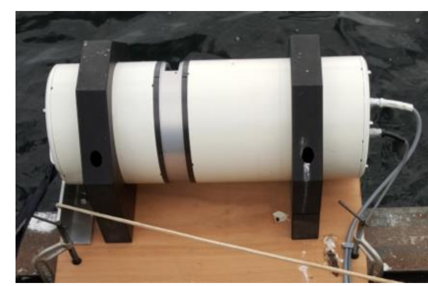
- University of Valencia – CIMEL CE312-2 (x 2)
- GOTA – CIMEL CE312-2
- JPL – Apogee SI-121
- KIT – Heitronics KT15.85 (x 2)
- STFC RAL Space – SISTeR
- CSIRO – ISAR
- University of Southampton – ISAR
- Ocean University of China – ISAR, OUCFIRST
- DMI – ISAR









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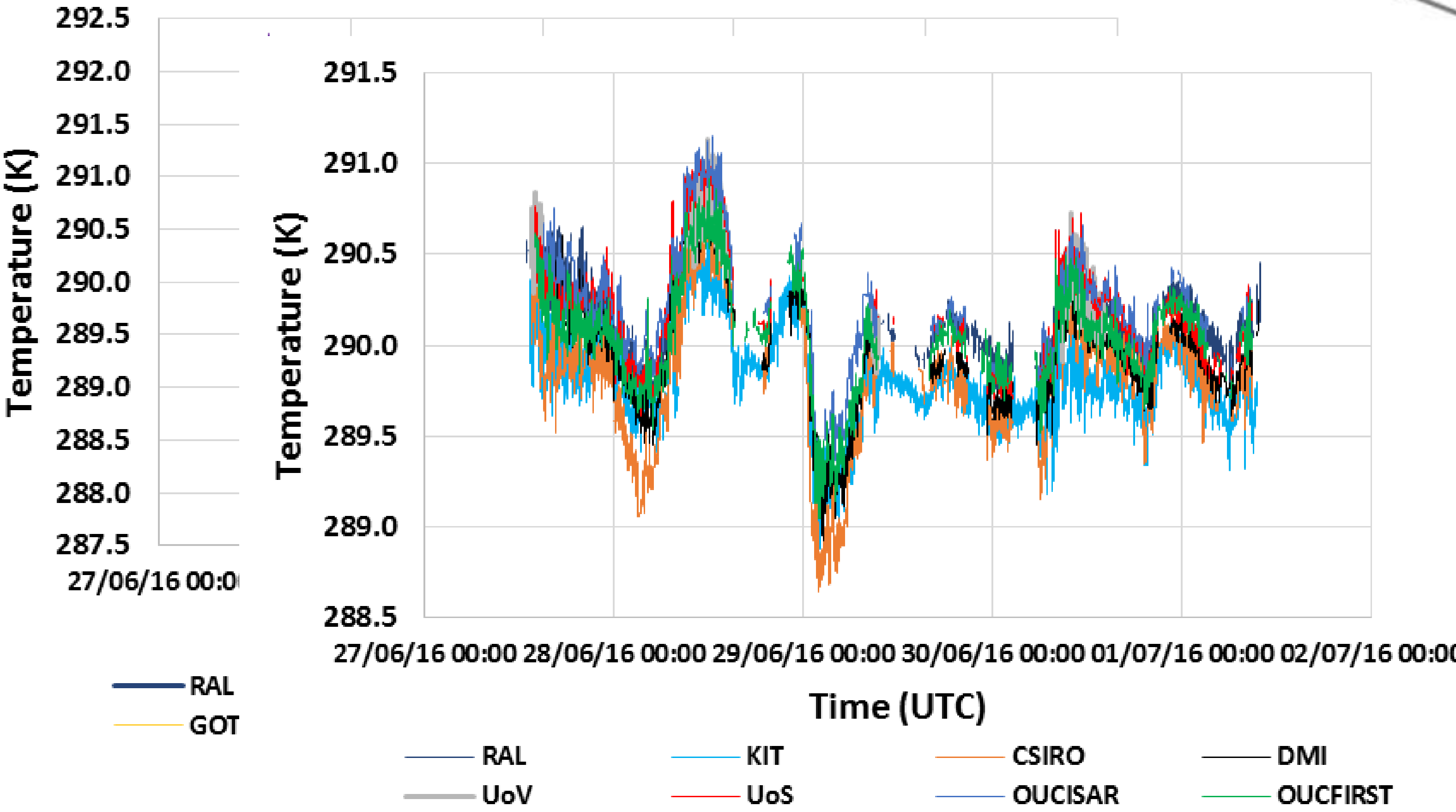
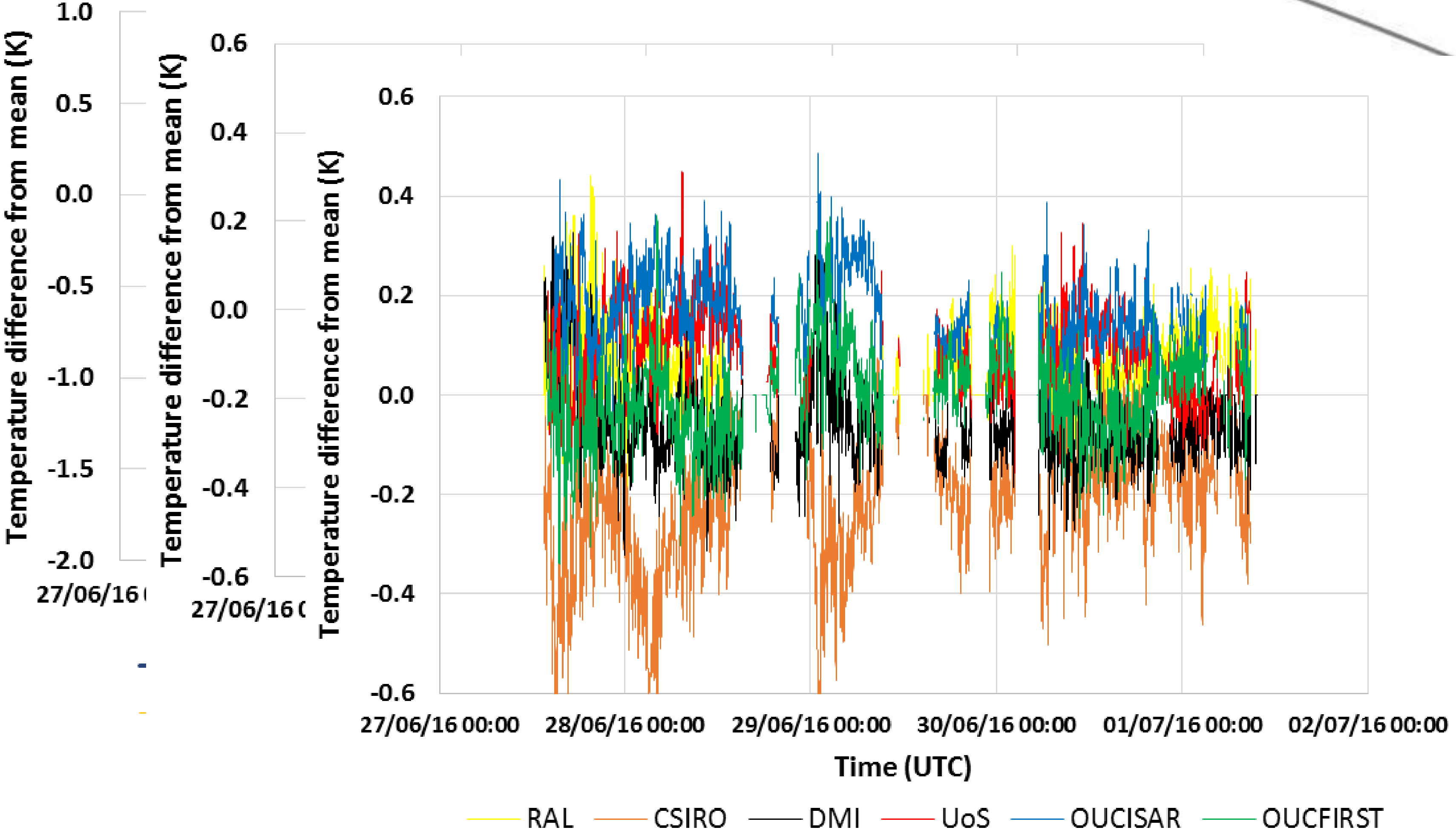
Wraysbury WST



Wraysbury WST difference from mean



Wraysbury WST
mean difference from mean

Radiometer	Mean difference from mean (K)		
	All	Night	Day
STFC RAL	0.123	0.136	0.111
KIT	-0.159	-0.114	-0.200
CSIRO	-0.189	-0.224	-0.164
DMI	-0.020	-0.025	-0.014
UoV	0.117		0.117
UoS	0.125	0.096	0.148
OUCFIRST	0.033	0.065	0.004
OUC-ISAR	0.206	0.206	0.206
GOTA	0.593		0.593
JPL	-0.109	-0.189	-0.032

Wraysbury summary

- Generally a successful campaign. No major hitches and all of the participating instruments operated for at least a part of the intercomparison period
- All instruments reproduced the same general WST features, though there were some detailed differences
- Instruments with a sky view showed significantly smaller deviations from the average WST than those without
- Instruments designed for SST measurements (all self-calibrating filter radiometers) showed the most consistent measurements

A few comments

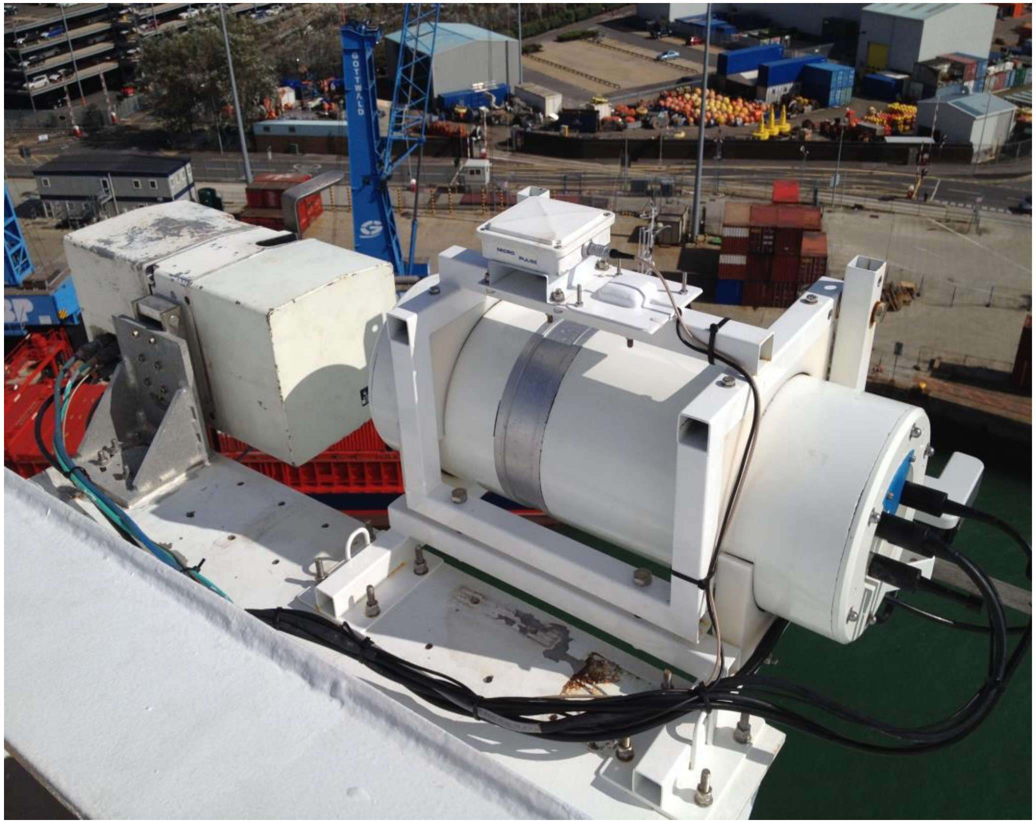
- The mean WST is not the “truth”
  - Different from level 1 laboratory intercomparison where a reference black body generates a known, stable radiometric signal (with uncertainties)
  - Dangerous to treat mean differences from mean WST as measures of individual instrument biases
- Some WST differences could be real
  - Different radiometers could sample systematic differences in water state
- It’s hard to design a perfect intercomparison
  - Ideally, all radiometers would view the same water spot, but hard to achieve in practice

QM2 intercomparison

- Prototype campaign for a bilateral radiometer intercomparison
- RAL Space SISTeR and University of Southampton ISAR mounted side-by-side on the Cunard *Queen Mary 2* liner
- High mounting position so both instruments see (nearly) the same water area
- Ship under way, so no problems with stagnant water and small-scale structure
- Two month deployment (11/09/2015 – 05/11/2015), but…
- …two weeks of measurements due to minor technical problems

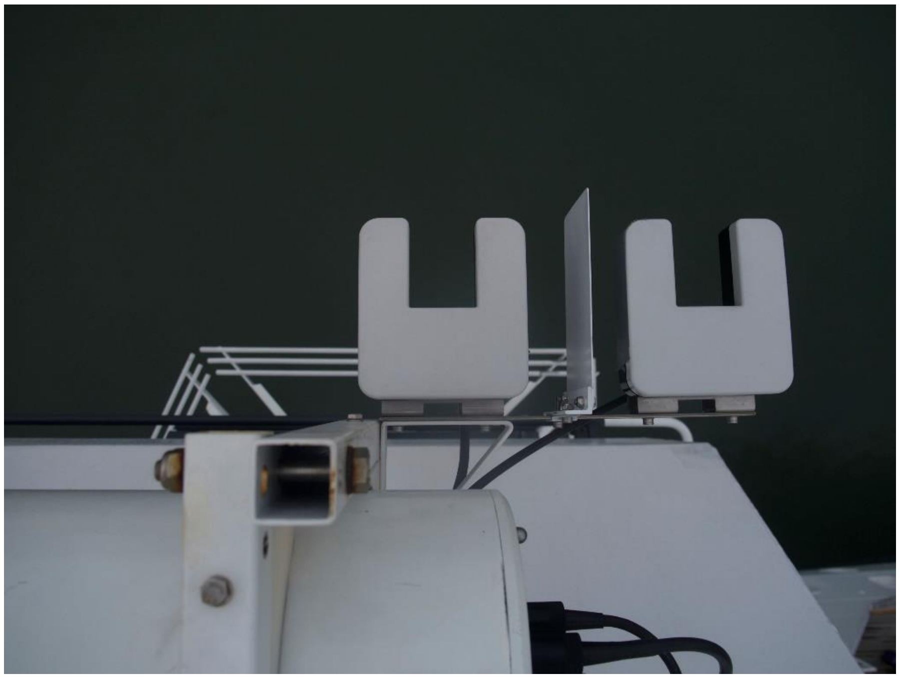
SISTeR on the QM2

QM2 installation



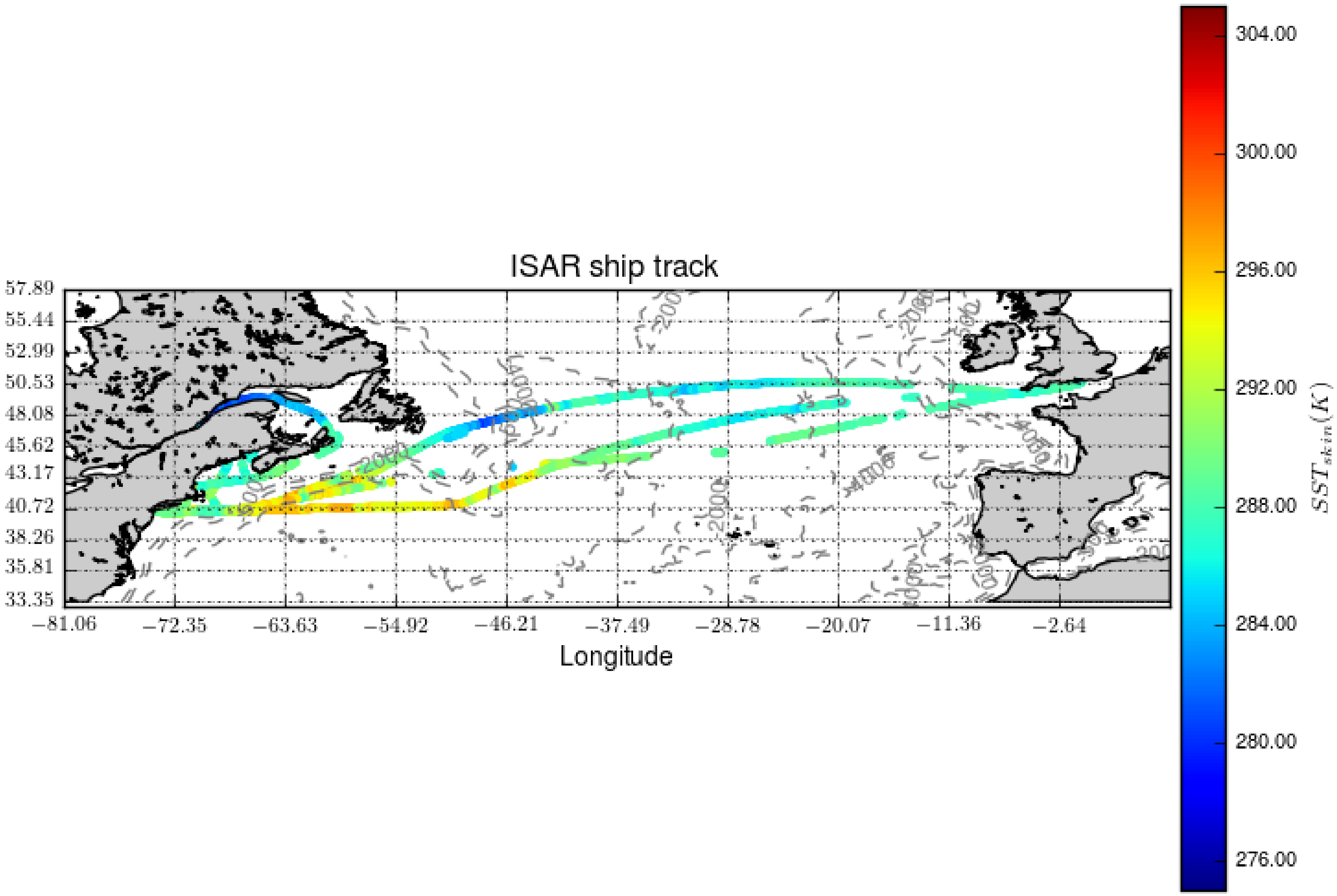
- Mounting table welded to side of “crow’s nest” above starboard bridge wing
- SISTeR in normal deployment position
- ISAR “borrowed” additional space and pre-installed electrical infrastructure

QM2 intercomparison

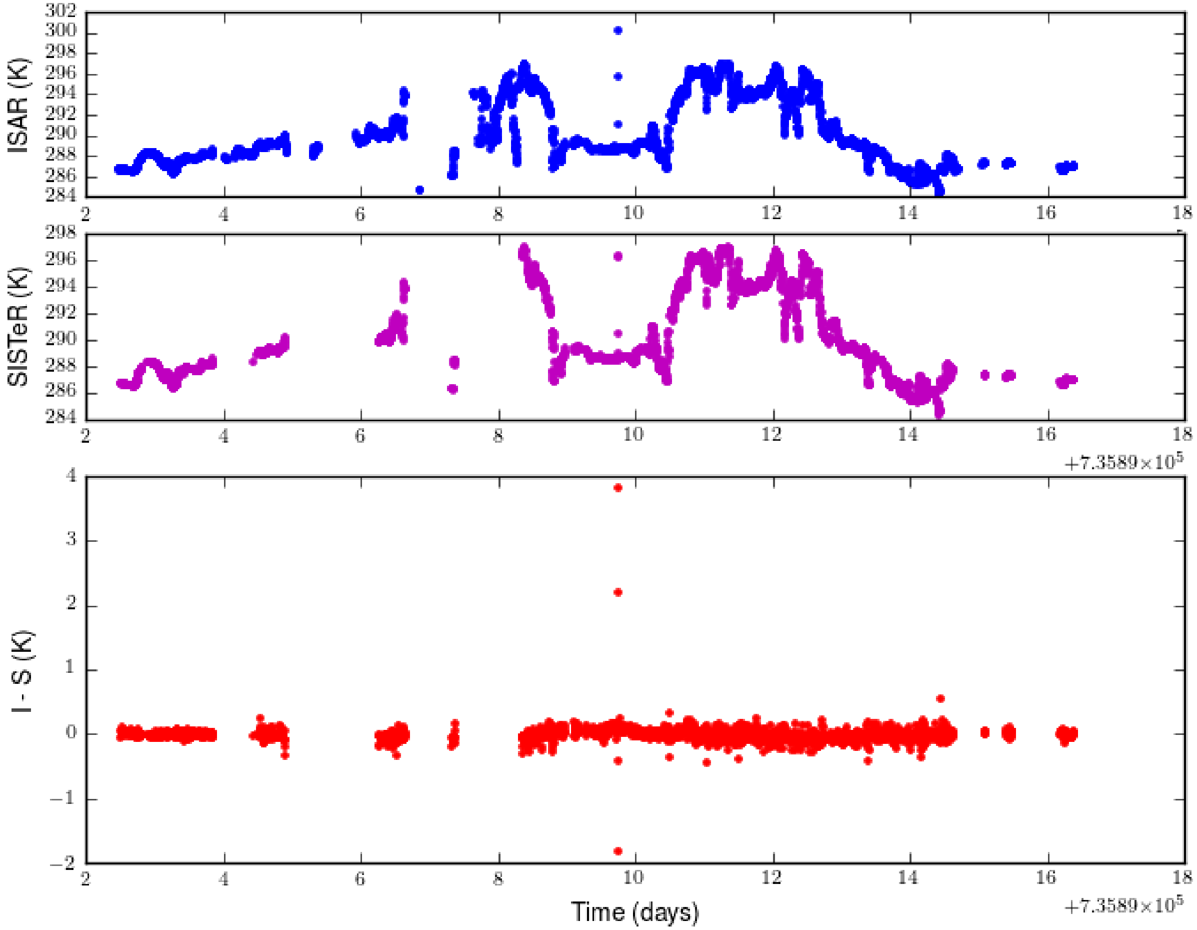


- Rain gauge issues
- SISTeR and ISAR use identical optical rain gauges to sense rain and spray
- Modulated NIR carrier signal scattered by droplets
- Each rain gauge saw the other's carrier signal – interpreted as rain
- Got it right at the third attempt
- Gauges mounted side-by-side with shielding plate

QM2 SST

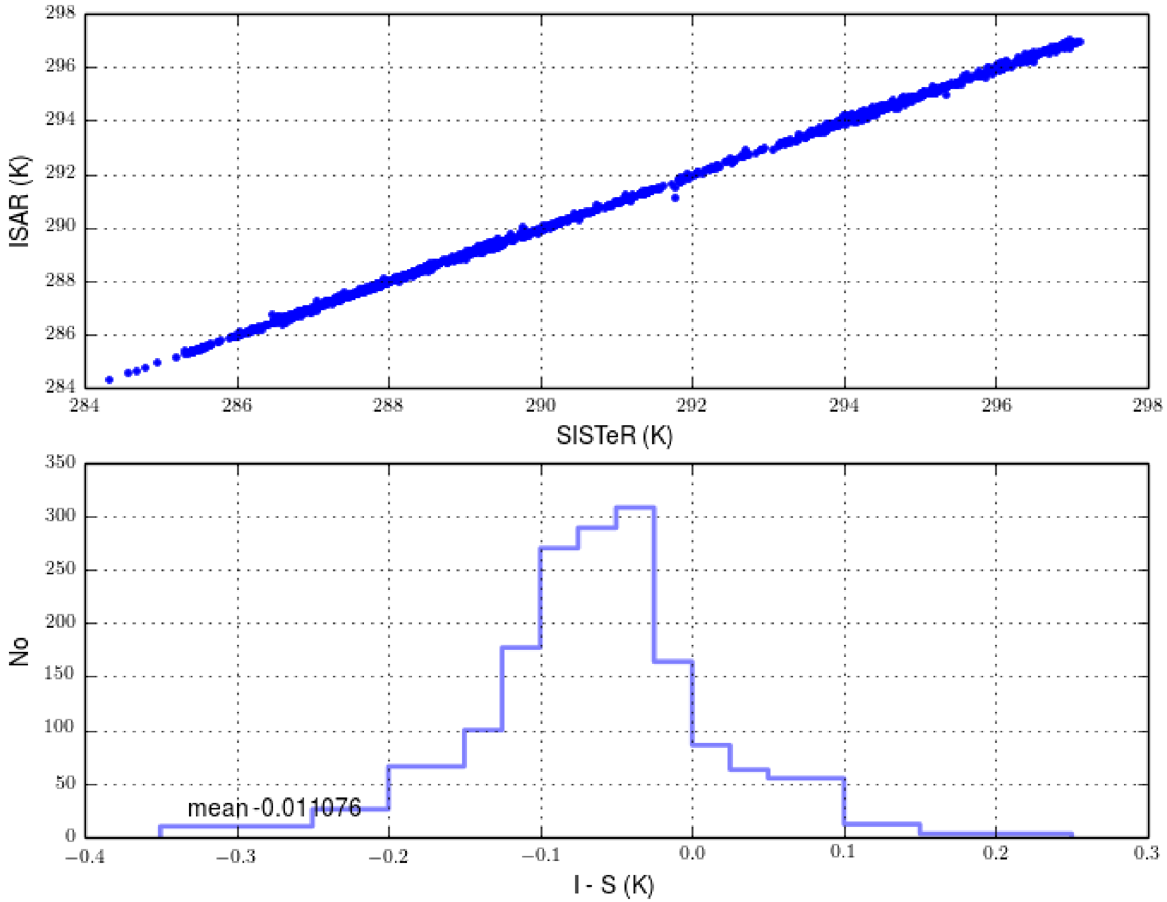

ISAR ship track
57.89
55.44
52.99
50.53
48.08
45.62
43.17
40.72
38.26
35.81
33.35
−81.06
−72.35
−63.63
−54.92
−46.21
−37.49
−28.78
−20.07
−11.36
−2.64
Longitude
304.00
300.00
296.00
292.00
288.00
284.00
280.00
276.00
$SST_{skin}(K)$

QM2 SST



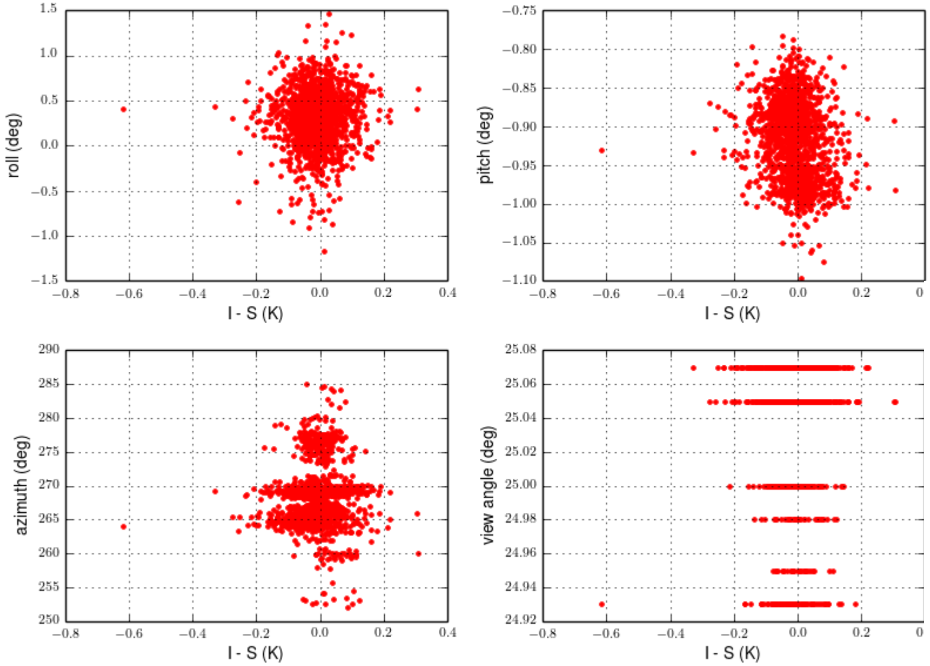
ISAR (K)
302
300
298
296
294
292
290
288
286
284
SISTeR (K)
298
296
294
292
290
288
286
284
I - S (K)
4
3
2
1
0
−1
−2
2
4
6
8
10
12
14
16
18
+7.3589×10^5
Time (days)

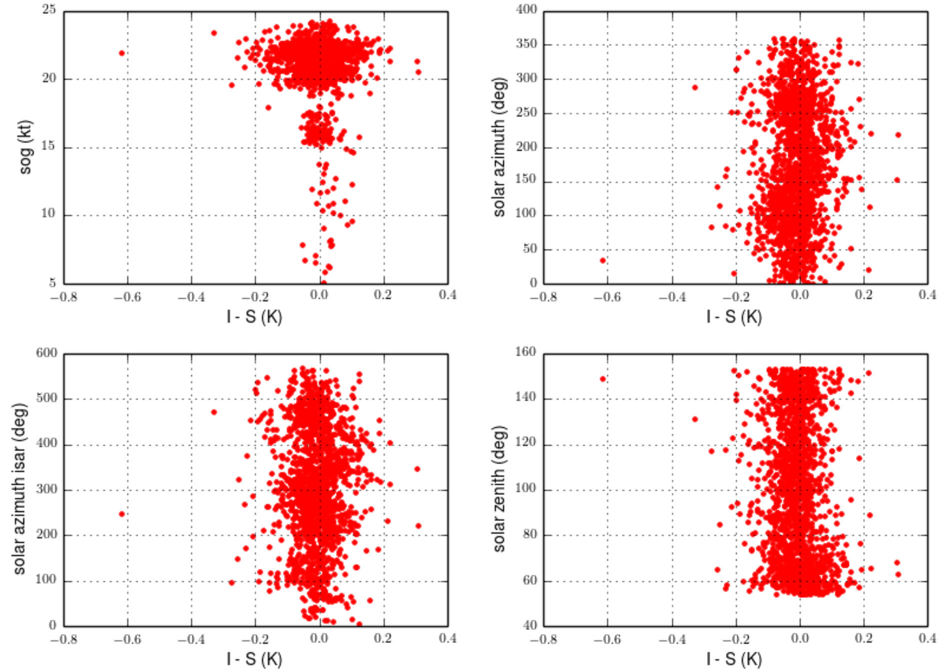
QM2 SST



ISAR (K)
SISTeR (K)
298
296
294
292
290
288
286
284
No
I - S (K)
mean -0.011076
350
300
250
200
150
100
50
0
−0.4
−0.3
−0.2
−0.1
0.0
0.1
0.2
0.3

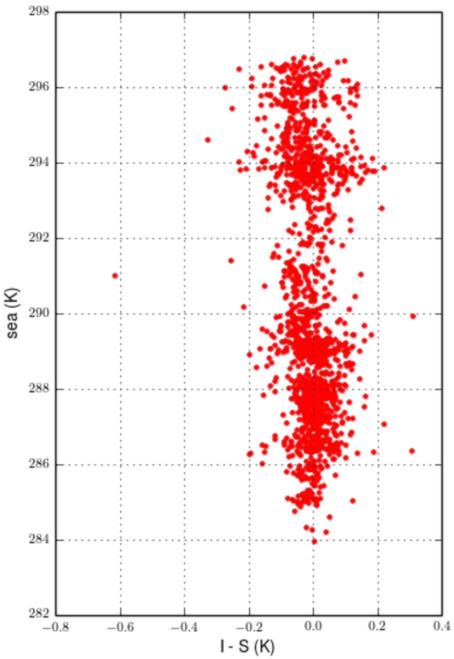
QM2 SST – trends

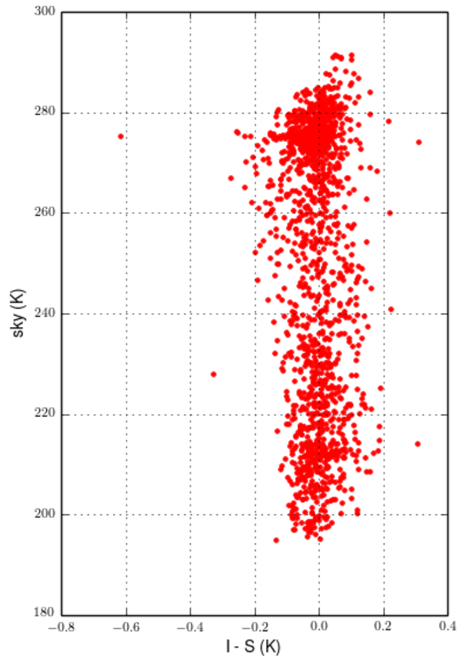


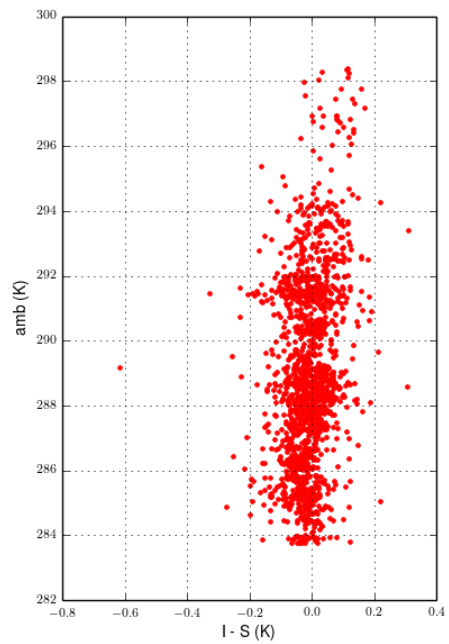


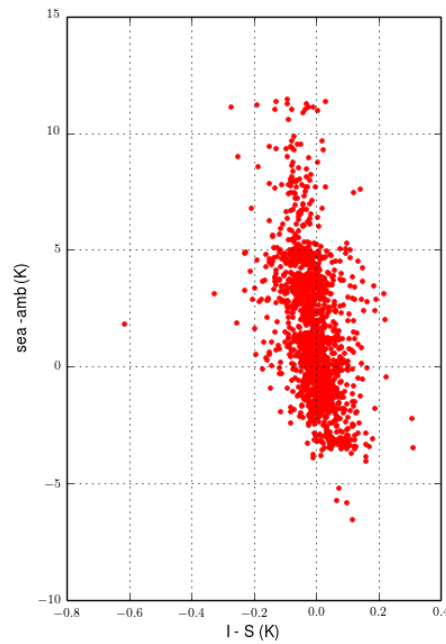
- No sensitivity to ship pitch, roll, speed; viewing direction; solar elevation and azimuth

QM2 SST – trends



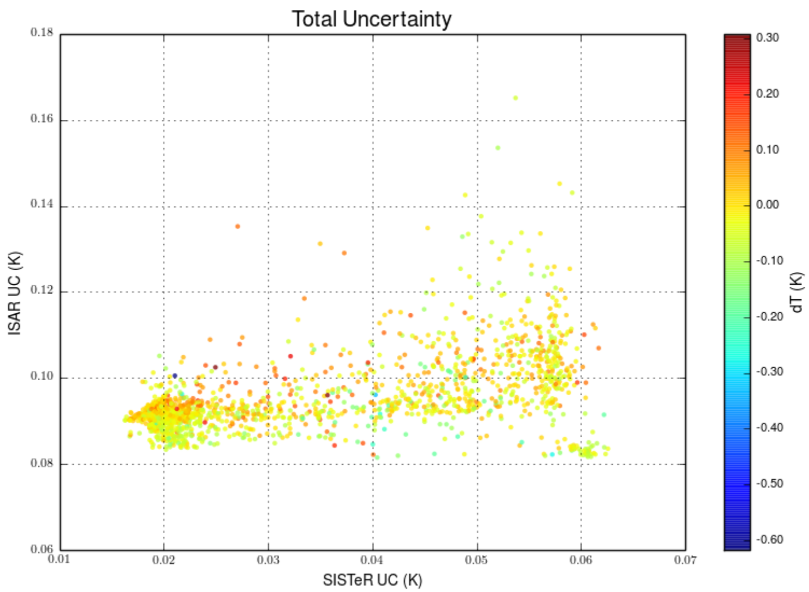


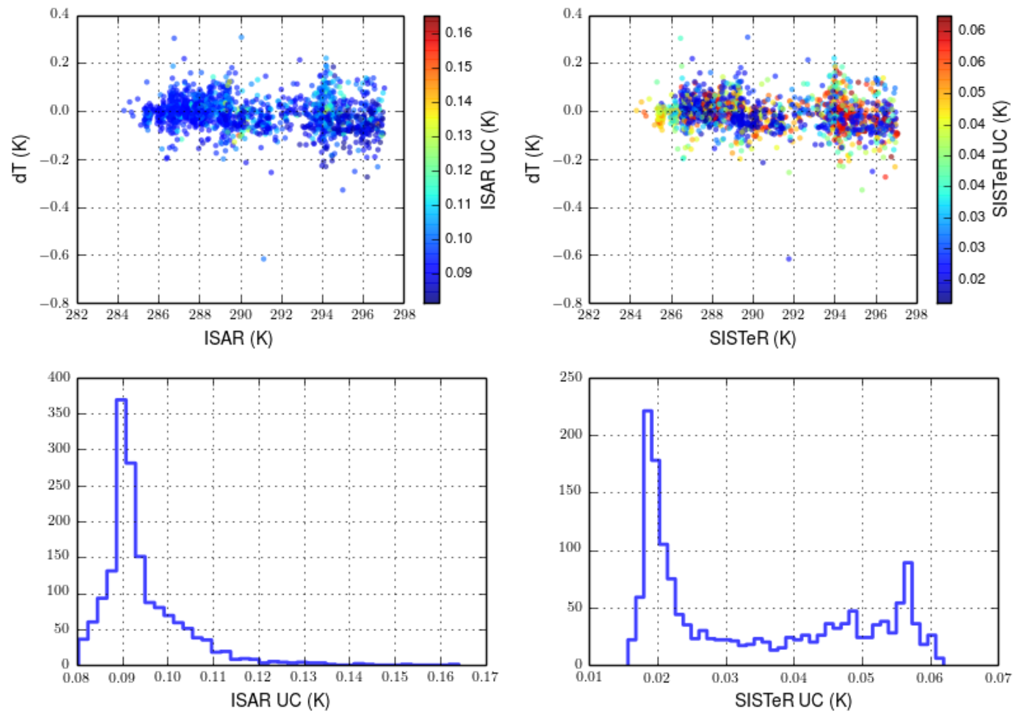




- No sensitivity to SST, sky BT but…
- …slight sensitivity to ambient instrument temperature

QM2 SST – uncertainties





- Instruments broadly agree on uncertainty trend, but sensitivities are significantly different

QM2 SST – summary

- Both instruments propagate type A and type B instrumental uncertainties through level 1 calibration equation and level 2 SST equation
- Some differences in interpretation:
  - SISTeR includes a sky radiance variability estimate, ISAR does not
    - Sky measurements are interpolated to sea measurements
    - Sky signal can be highly variable under broken cloud
  - ISAR includes an SST variability estimate in averaged SSTs, SISTeR does not
- Instruments agree, mostly, to within their 1σ uncertainty estimates
  - Biggest discrepancies at ocean fronts – mostly a sampling problem
- Not enough coincident information yet for a thorough investigation, particularly for the validation of uncertainties
- Future possibilities could include three-way uncertainty analysis, maybe including satellite SST measurements, but again, need more data!