ships4sst

shipborne radiometers for sea surface temperature

Radiometer Uncertainty Models

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Space ConneXions

Overview

- Uncertainty
- The ISAR model
  - Principle design
  - Estimating values
  - Some results
- Validation of uncertainty models
  - QM2 with SISTeR
  - AMT two ISARS
- A updated model – ISAR UC v2
- Conclusions

Uncertainty

When reporting the result of a measurement of a physical quantity, it is obligatory that some quantitative indication of the quality of the result be given so that those who use it can assess its reliability. Without such an indication, measurement results cannot be compared, either among themselves or with reference values given in a specification or standard. It is therefore necessary that there be a readily implemented, easily understood, and generally accepted procedure for characterizing the quality of a result of a measurement, that is, for evaluating and expressing its uncertainty.

Evaluation of measurement data — Guide to the expression of uncertainty in measurement

Uncertainty

Classic

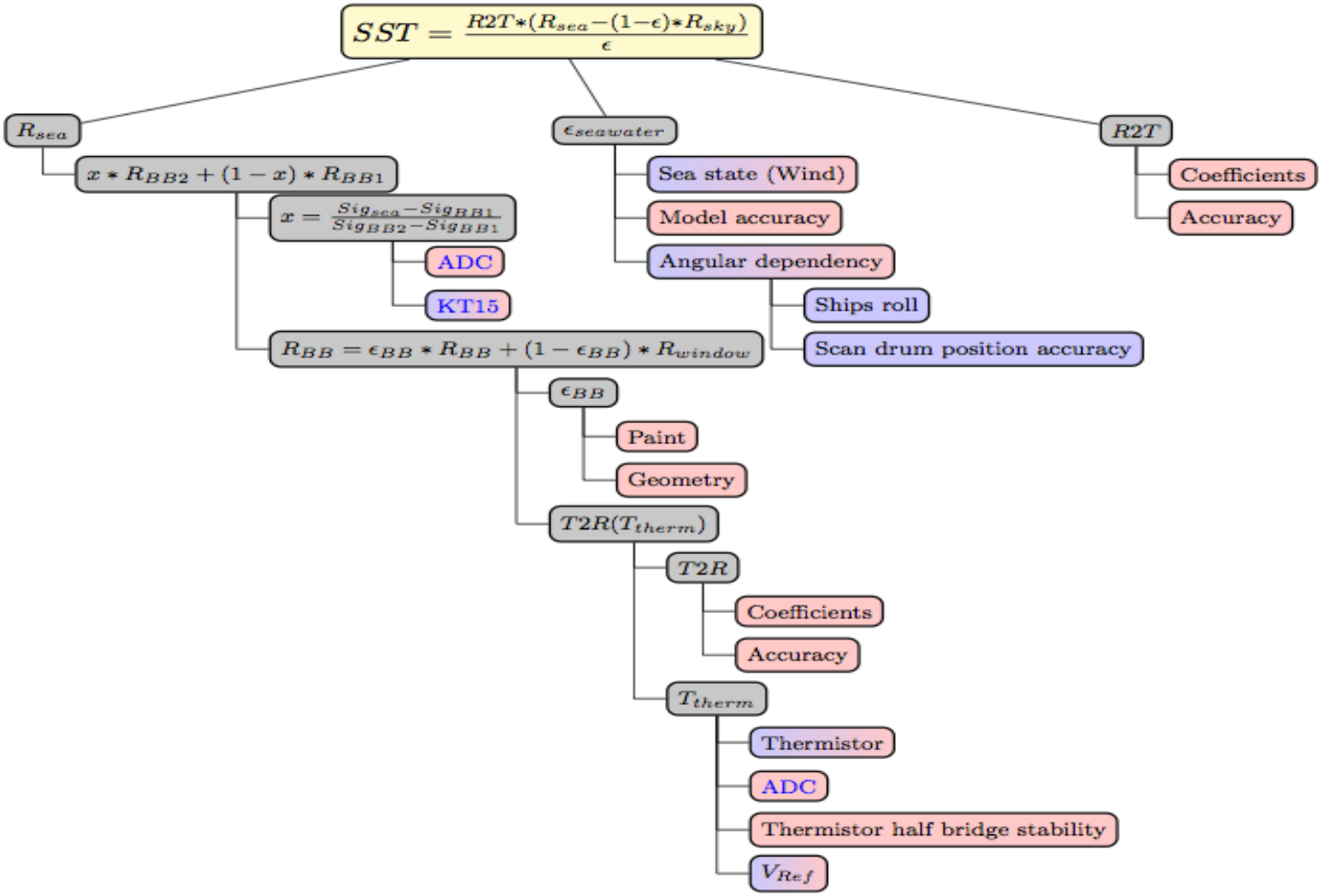
Adding all uncertainties in quadrature

Self calibrating radiometer

Measurement equation

BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML. Guide to the Expression of Uncertainty in Measurement. International Organization for Standardization, Geneva. ISBN 92-67-10188-9, First Edition 1993, corrected and reprinted 1995. (BSI Equivalent: BSI PD 6461: 1995, Vocabulary of Metrology, Part 3. Guide to the Expression of Uncertainty in Measurement. British Standards Institution, London.)

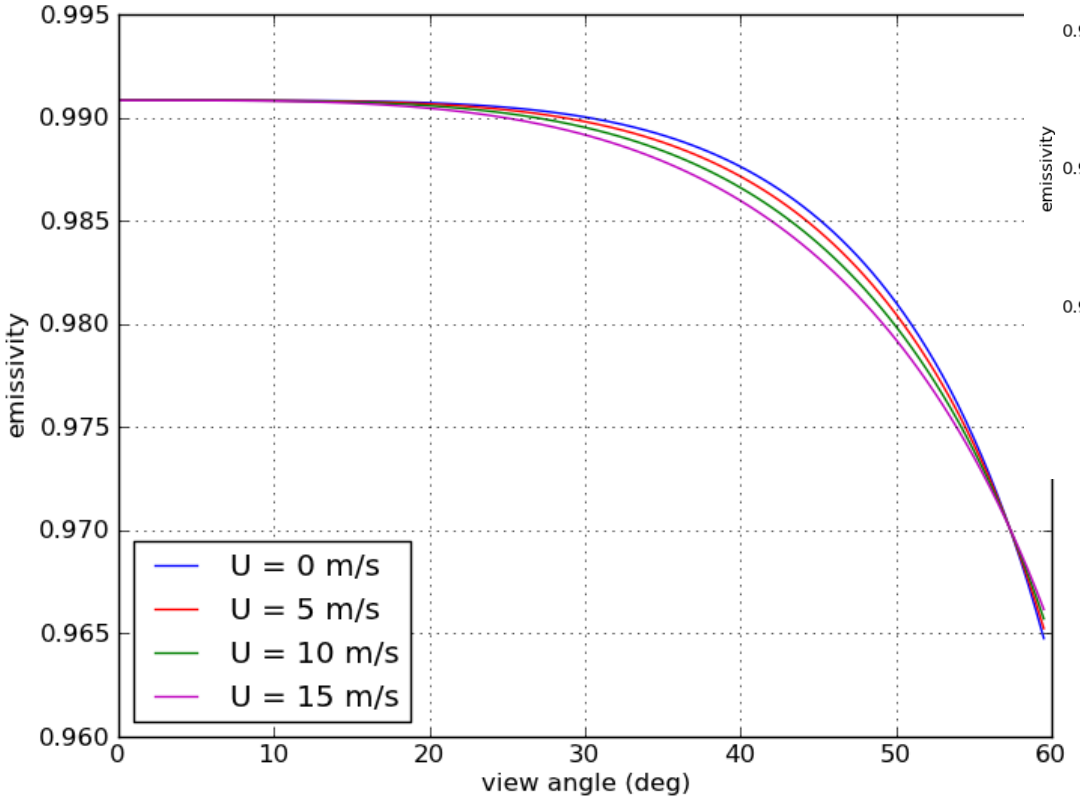
Uncertainty – radiometers

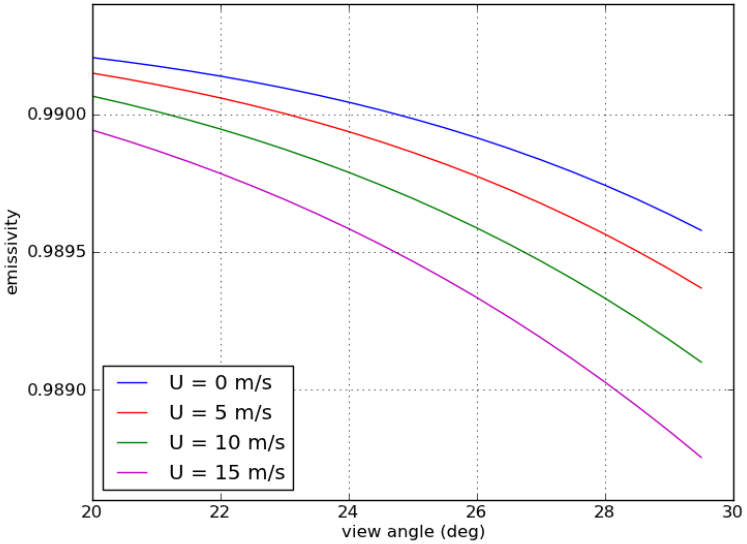


Uncertainty – values

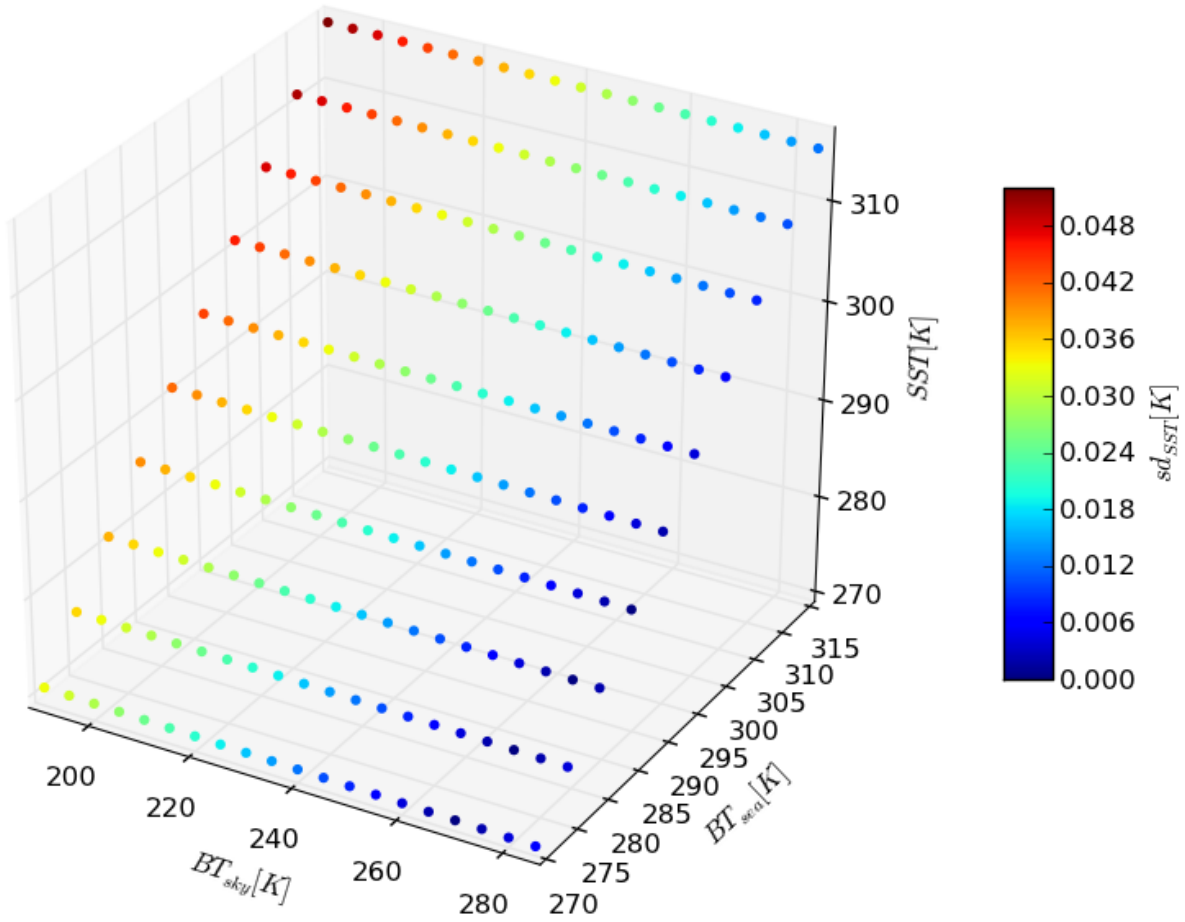
Item (X_i)	Uncertainty ($u(x_i)$)	Unit	Uncertainty type
Detector linearity	< 0.01%	K/month	B
Detector noise	~0.002	Volts	A
Detector accuracy	± 0.5	K	B
Analogue to Digital converter (ADC)	± 1	LSB	B
ADC accuracy	± 0.1%	Range	B
ADC zero drift	± 6	µV /C	B
Reference voltage 16 bit ADC	± 15	mV	B
Reference voltage 12 bit ADC	± 20	mV	B
Reference resistor	1	%	B
Reference resistor temperature coefficient	± 100	Ppm/C	B
Black Body emissivity	± 0.000178	emissivity	B
Sea surface emissivity	± 0.07	emissivity	B
Steinhart-Hart approximation	± 0.01	K	B
Radiative transfer approximation	± 0.001	K	B
Thermistor	± 0.05	K	B
Thermistor noise	~0.002	Volts	A

Uncertainty – emissivity



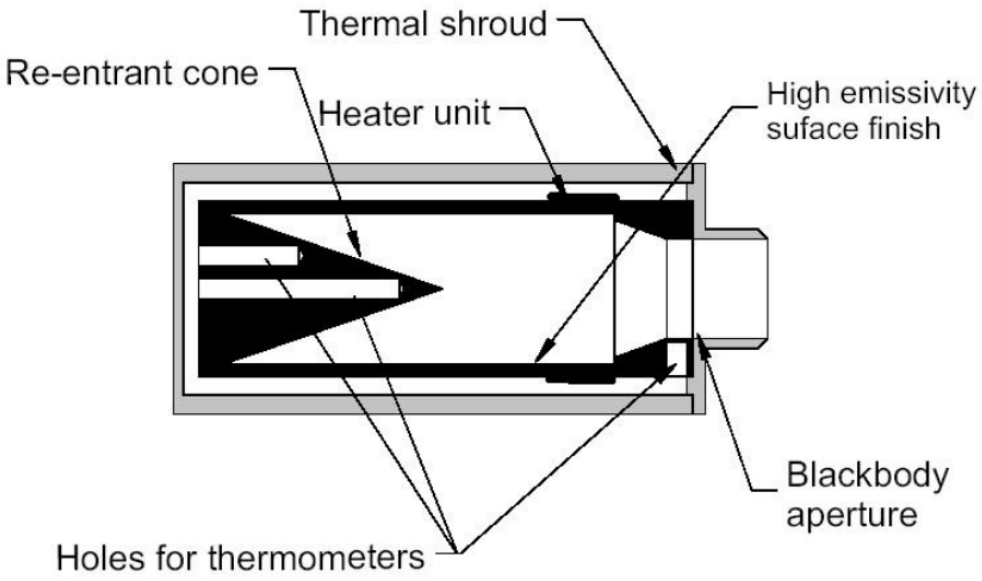


Uncertainty – emissivity effect on SST



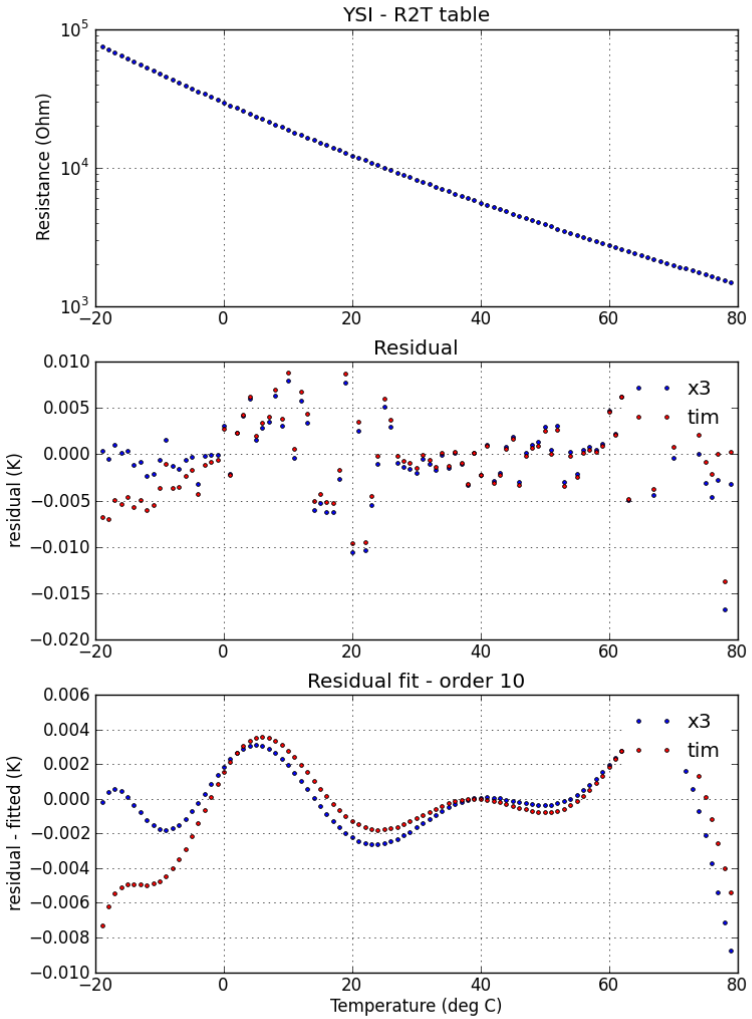
Uncertainty – black bodies

- Emissivity 0.9993 +/- 0.000178
  - Estimated through modelling

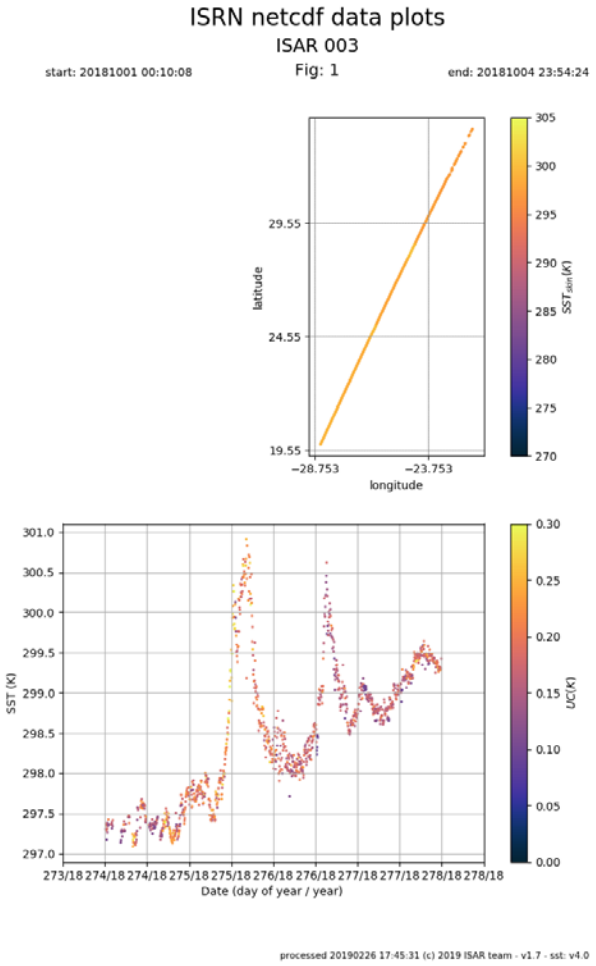


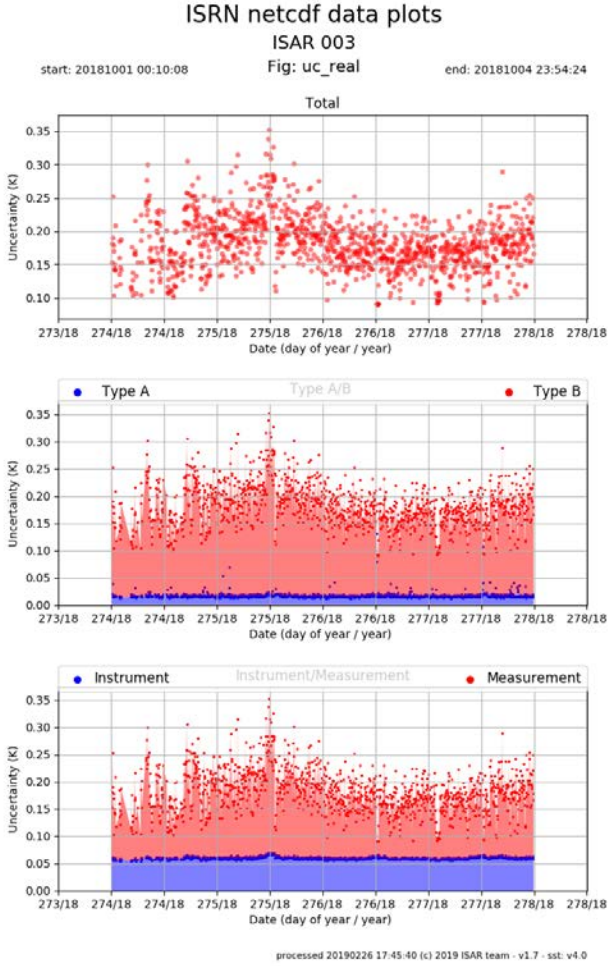
Uncertainty – thermistors

- 0.05K

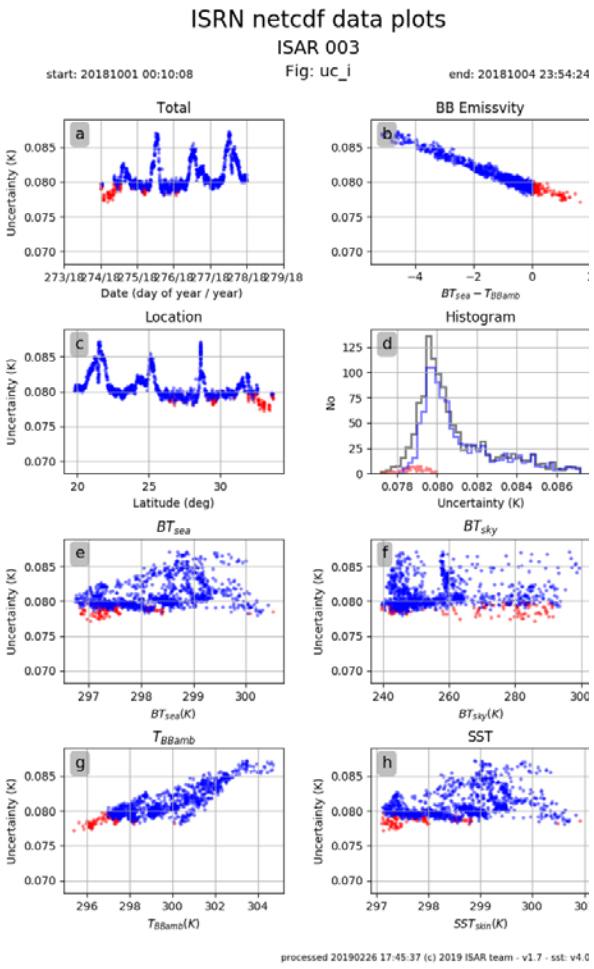


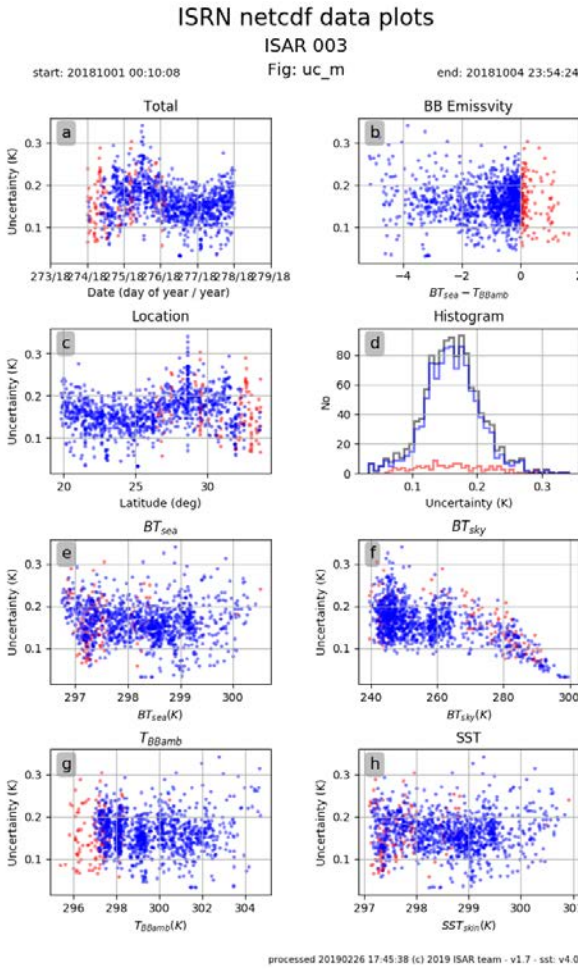
Uncertainty – results

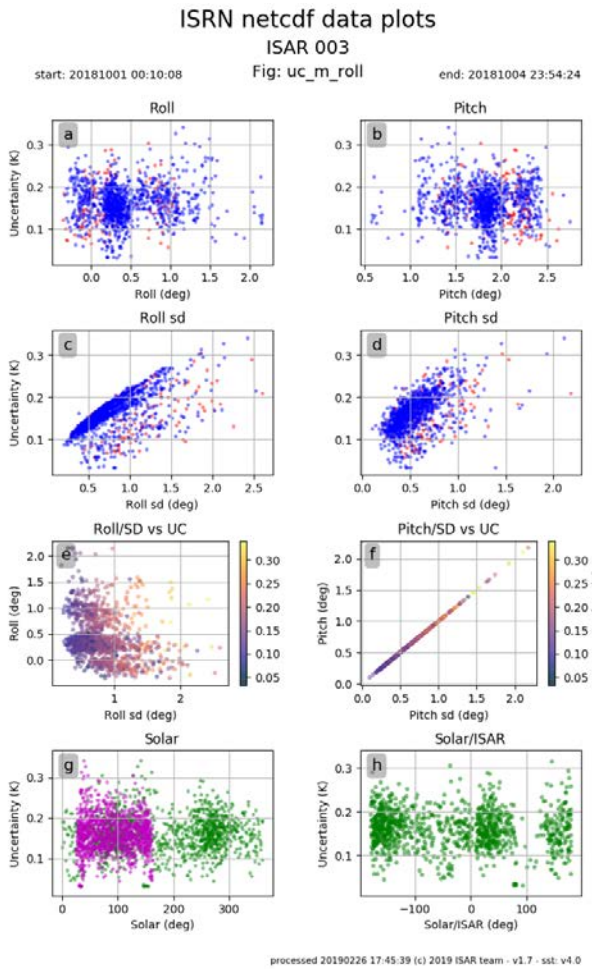




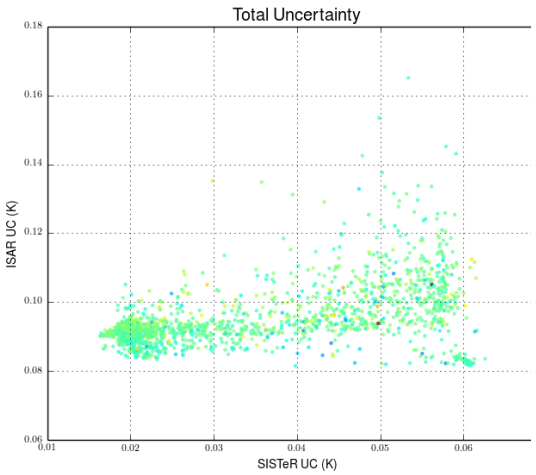
Uncertainty – results

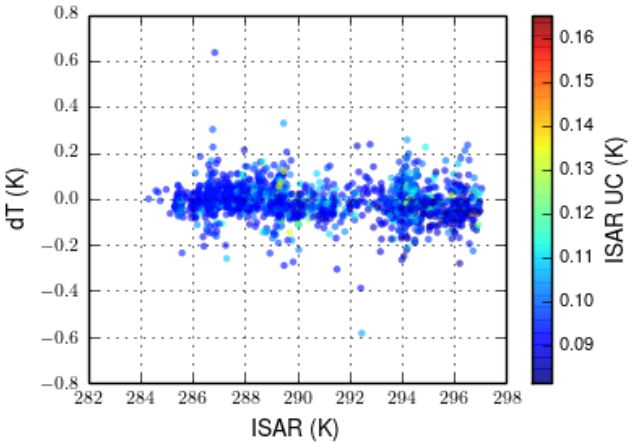


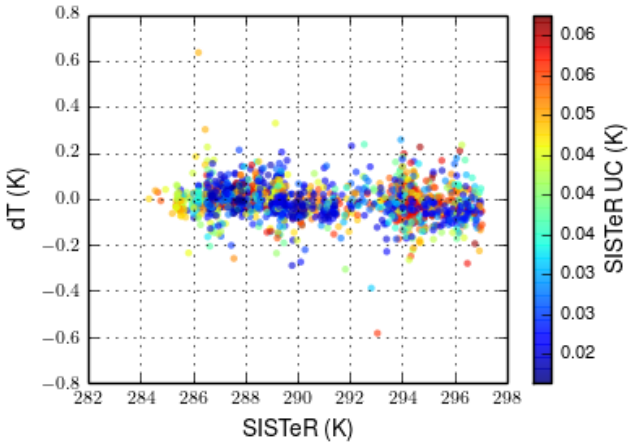


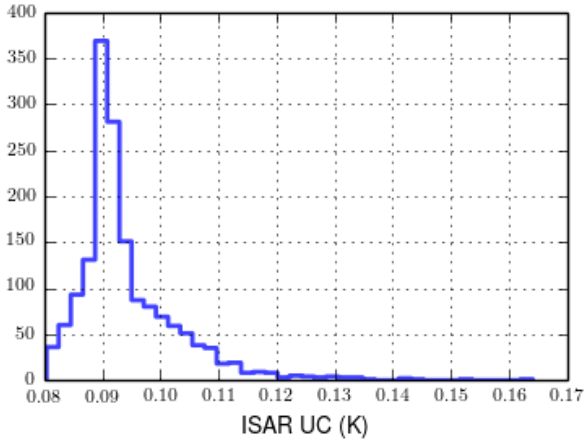


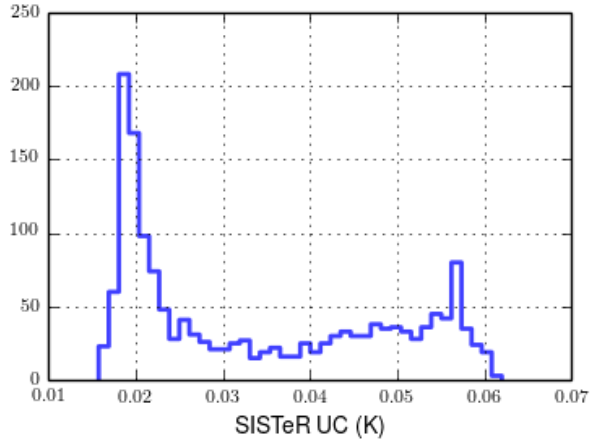
Uncertainty – validation – QM2



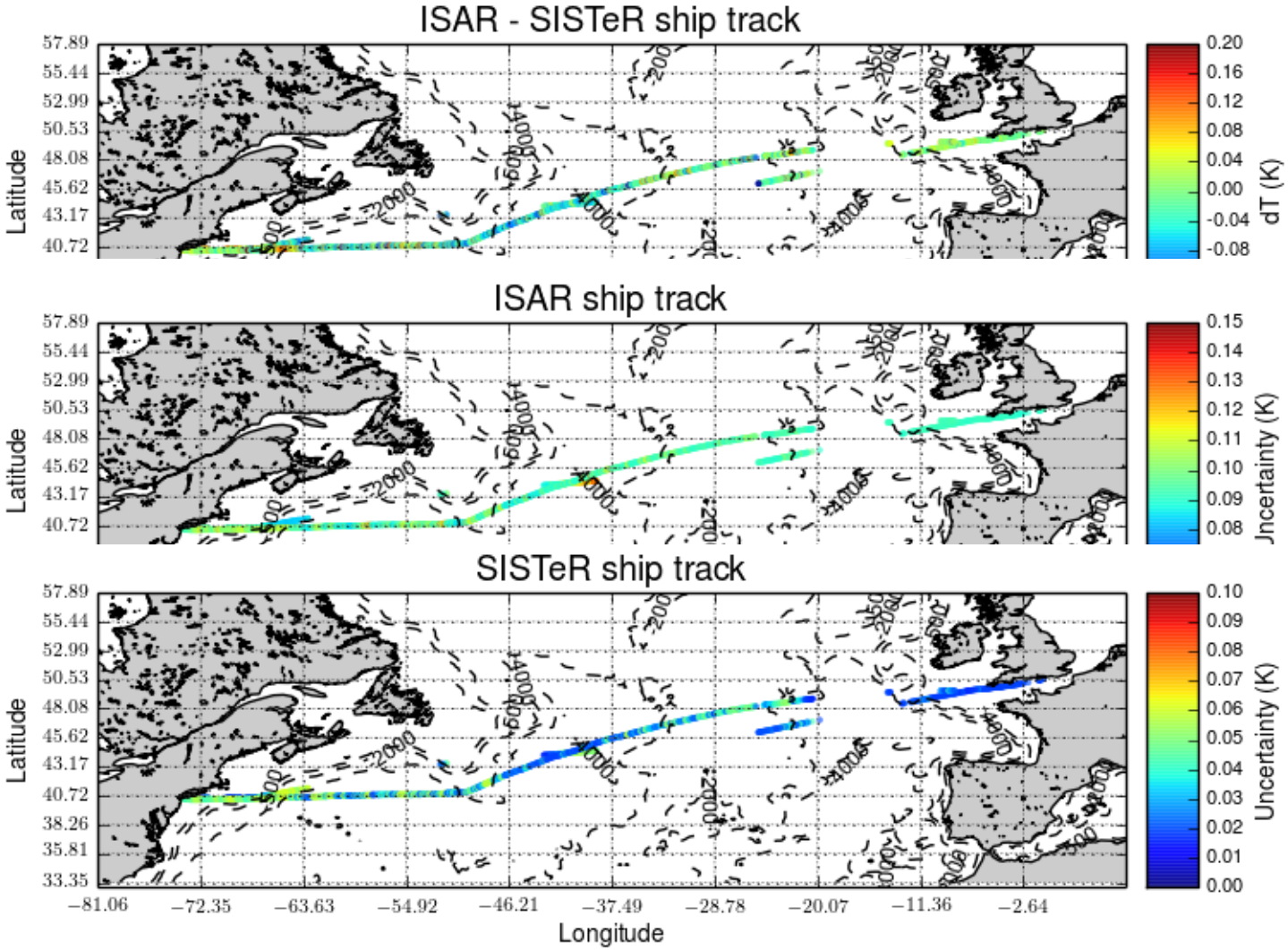




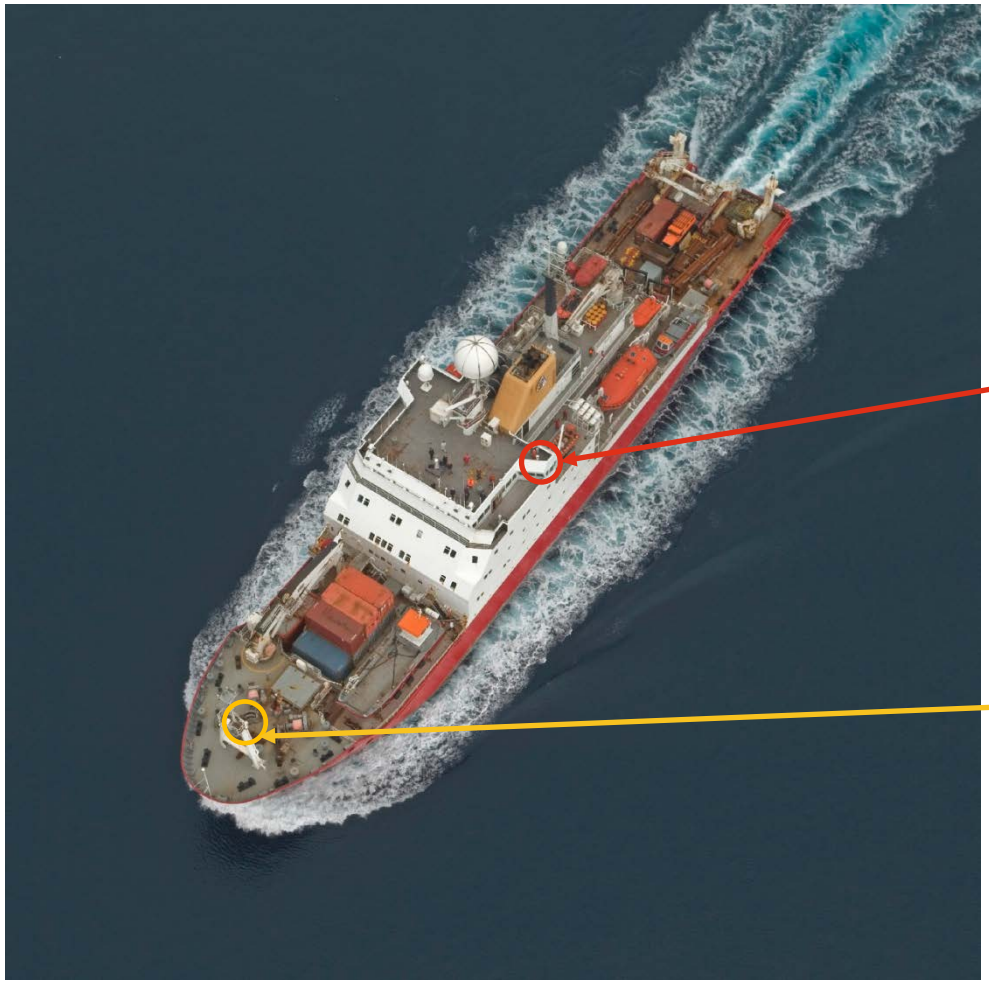




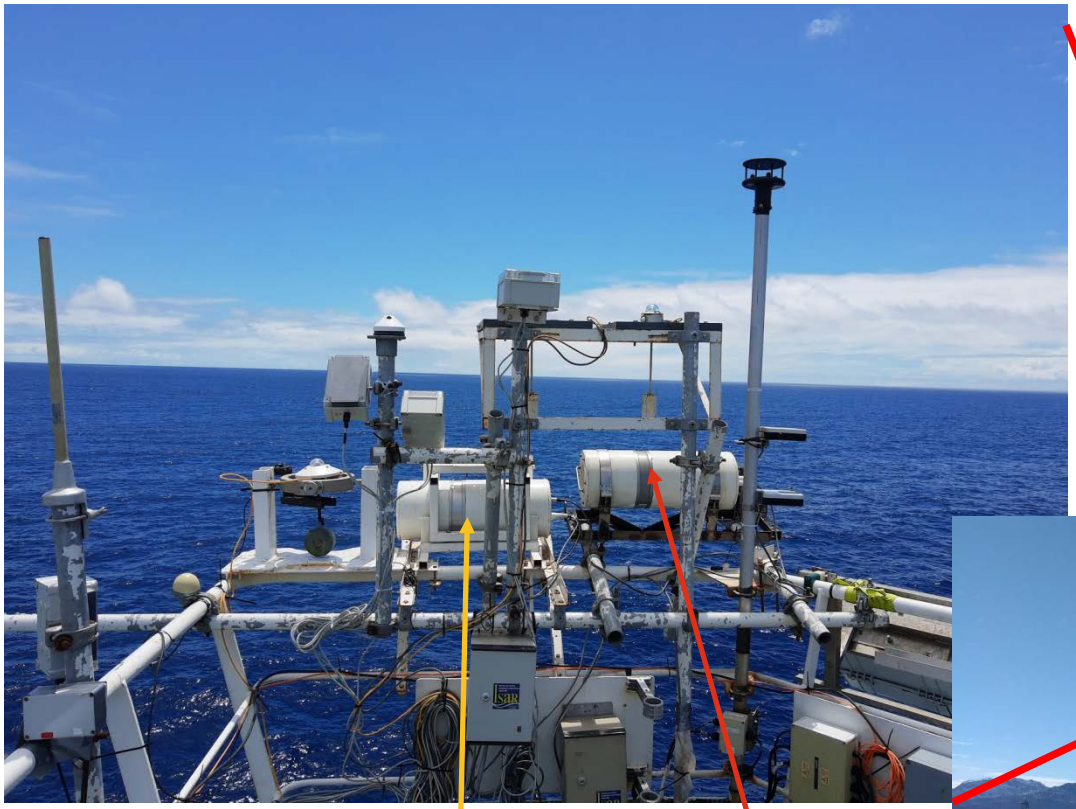
Uncertainty – validation QM2

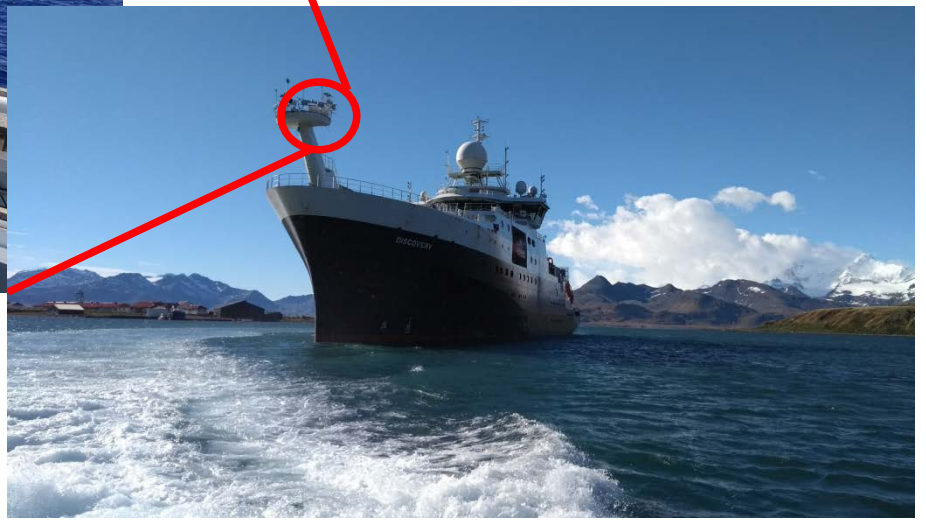


Uncertainty – validation - AMT28



Uncertainty – validation - AMT29



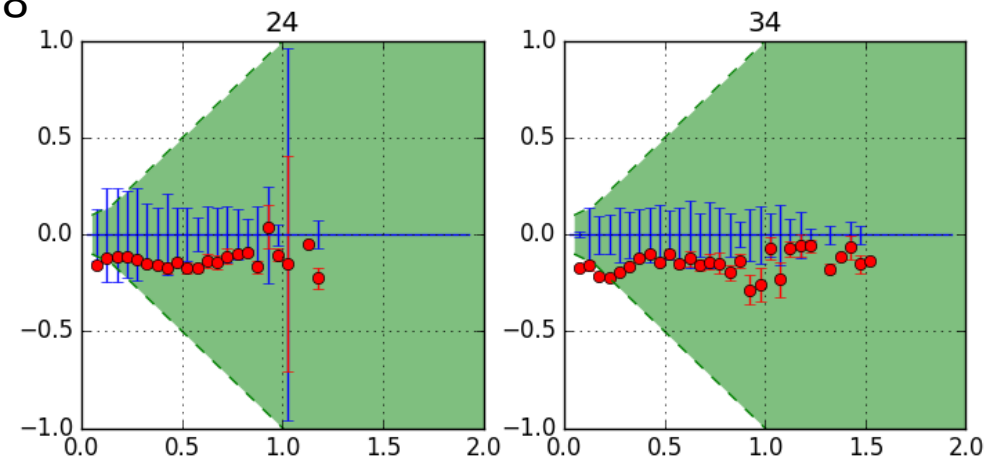


ISAR 003

ISAR 007

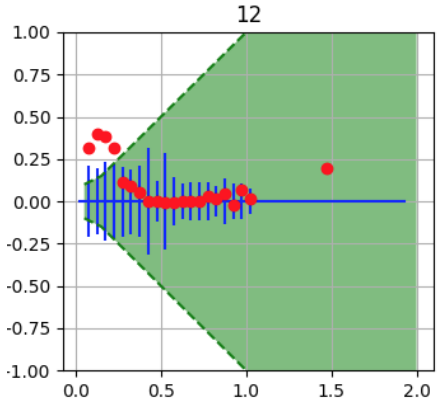
Uncertainty – validation - AMT

AMT28



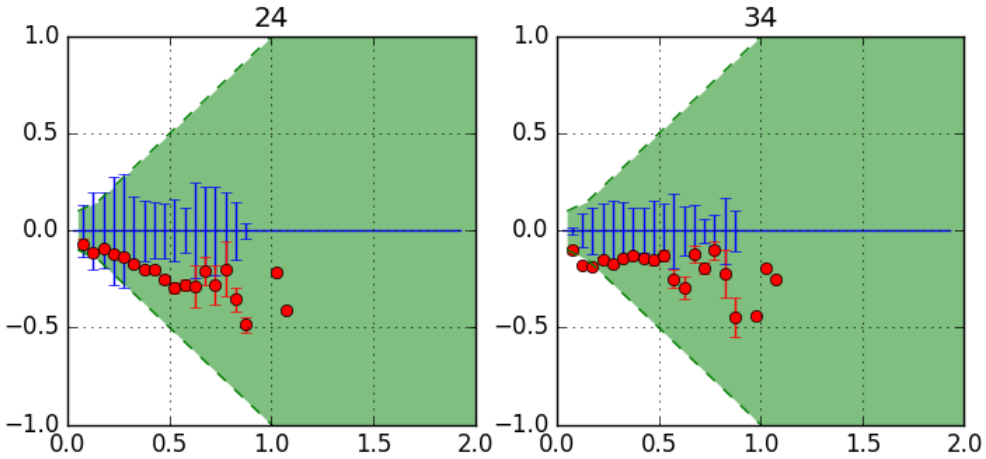
1: 25 - 12
2: 35 - 12
3: 45 - 12
4: 35 - 3

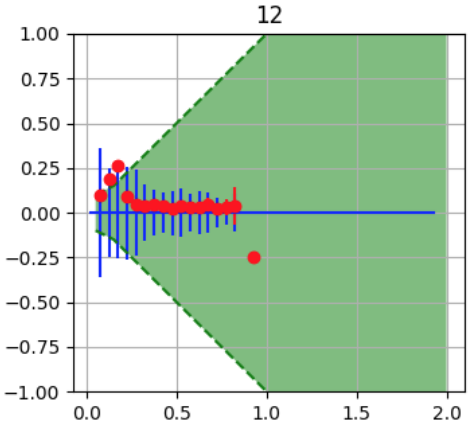
AMT29



UC 12

UC 07

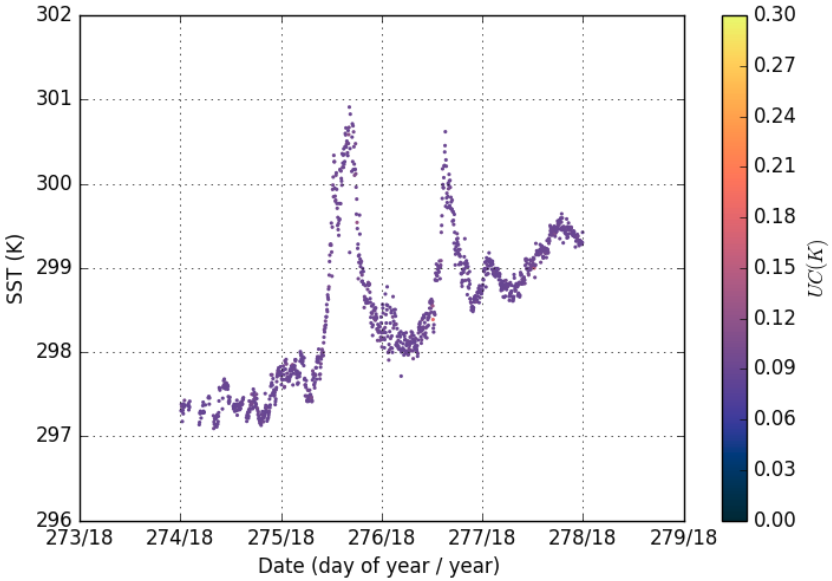


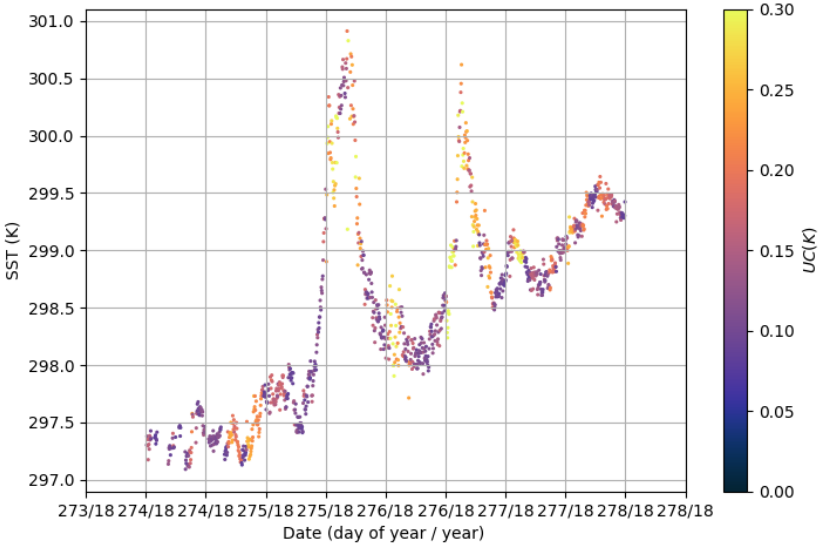


UC 03

Uncertainty – validation – AMT – v2

- Changes to v1
  - Roll is Hanning filtered, length is 11 values
  - Sky, sea signal over 5 SST samples
    - Centre Weighted average - 1, 4, 4,1
    - Variance of the gets added to the sea and sky signal uncertainty before calibration
    - SST weighted std gets added to final SST uc in quadrature





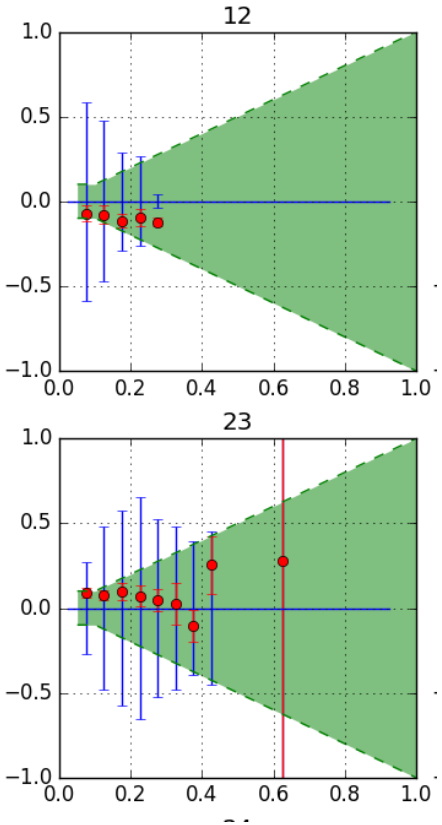
processed 20181204 18:16:36 (c) 2018 ISAR team - v1.7 - sst: v4.1

processed 20190226 18:09:15 (c) 2019 ISAR team - v1.0 - sst: v 4.1

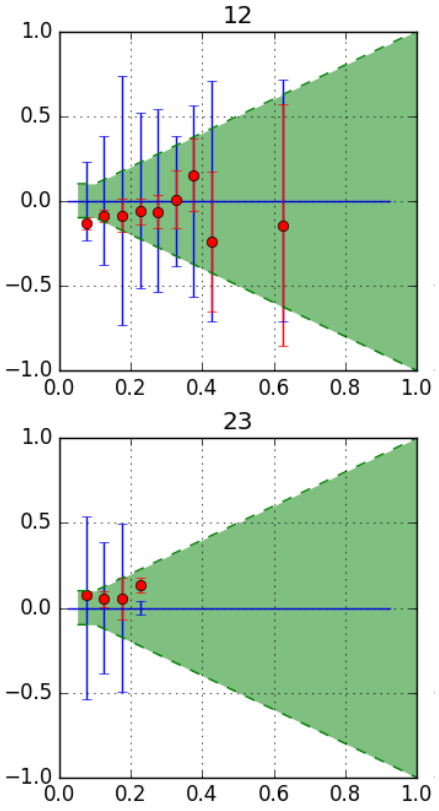
Uncertainty – validation – AMT – v2

1: 35 – 12 - idx
2: 35 – 03 - final
3: 45 – 12 - sroll
4: 35 – 3 - idx

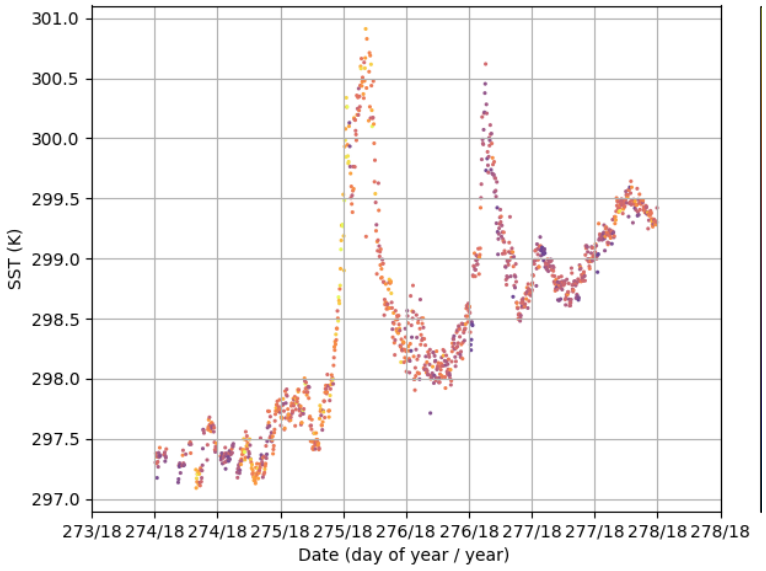
UC 12



UC 03



Uncertainty – validation – AMT – v2



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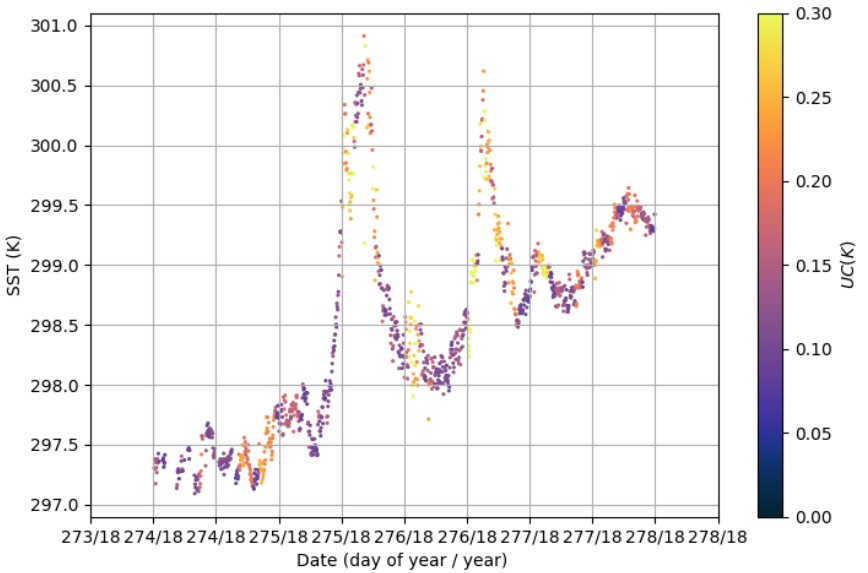

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Threeway error

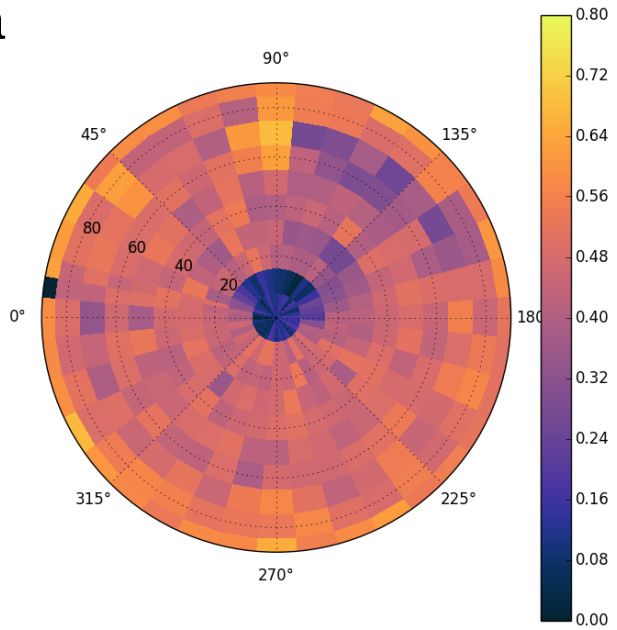
- Classic
  - AMT 28 / AMT 29
  - ISAR 03 : 0.0992 K / 0.0747 K : ISAR 03
  - ISAR 12: 0.2077 K / 0.1286 K : ISAR 07
  - Seabird: 0.2373 K / 0.2335 K : Seabird
- Challenor et.al.
  - ISAR 03 : 0.0835 K / 0.0736 K : ISAR 03
  - ISAR 012: 0.1603 K / 0.0779 K : ISAR 07
  - Seabird: 0.1899 K / 0.1678 K : Seabird
- View angle is 145/35 degrees
  - Issues with ships wake for ISAR 012

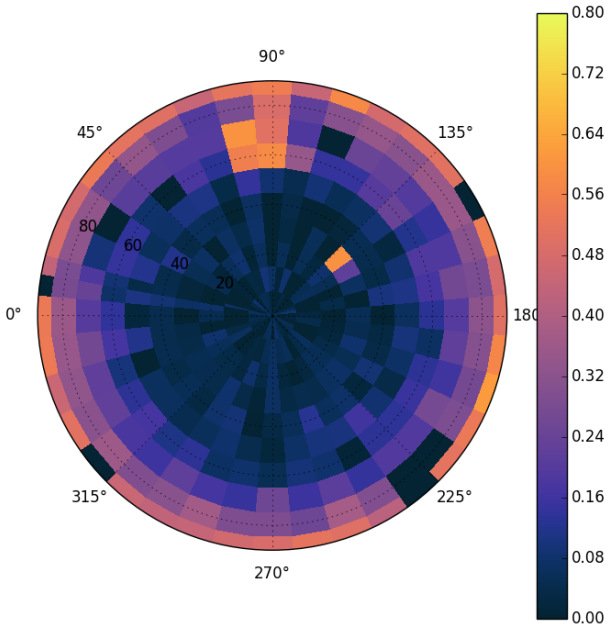
Conclusion

- Uncertainty model
  - Principle is relatively straight forward
  - Potentially lots of components and covariance matrix might be tricky to resolve
  - Numbers are sometimes difficult to estimate
- ISAR uncertainty model
  - Was first of its kind
  - Instrument uncertainty seems right
  - Measurement uncertainty overestimates
    - Roll dependence of emissivity
- Uncertainty model validation
  - Not easy to achieve
  - Showed instrument uncertainty is ok – QM2
  - Also showed measurement uncertainties generally over estimate but do not capture SST gradients well
  - V2 in progress

Future Work

- Uncertainty model v2
  - Progress since last workshop limited
    - Update of code to python 3
  - Need verification on AMT29 data
- Look at sky BT data from AMT
  - Skypan data
  - Sky IR data





Future Work