# The SISTeR processor

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## Introduction

The SISTeR in-situ radiometer is a validation radiometer and, as such, must generate traceable estimates of SST, including estimates of the associated type A and type B uncertainties. We describe the design of a new SISTeR processor that propagates uncertainty estimates in parallel with the contributing terms to the calibration and SST equations.

Rather than calculating level 2 SSTs from level 1 radiances in the traditional way, the SISTeR processor generates a synthetic SST signal count and calibrates this, to avoid double-counting calibration uncertainties.

The SST equation is partitioned to include an air temperature anomaly as, in the absence of direct measurements, the anomaly generally can be better estimated than the gross air temperature.

The processor outputs level 1, 2 and 3 products. The level 2 and 3 products are generated in an "L2R" format that closely follows GHRSST product design principles and all three are CF and ACDD compliant.

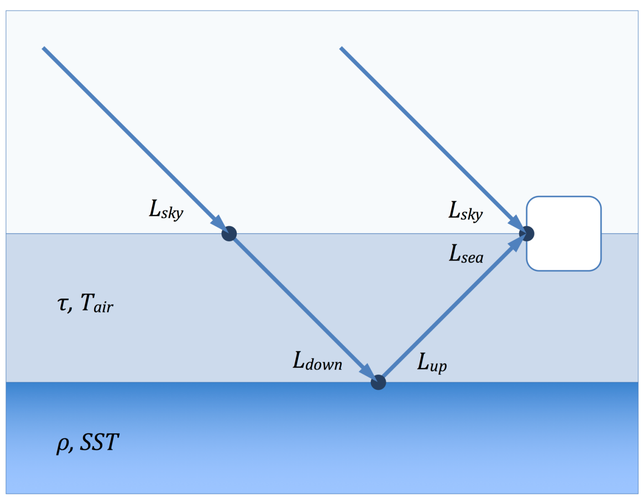
## Level 1 calibration equation

For an instrument with a linear response to radiance, the level 1 calibration equation is:

$$\frac{L_{scene} - L_{BB1}}{L_{BB2} - L_{BB1}} = x = \frac{c_{scene} - c_{BB1}}{c_{BB2} - c_{BB1}}$$

where $L_{BB1}$, $L_{BB2}$ and $L_{scene}$ are the radiances of the two black bodies and the external scene, $c_{BB1}$, $c_{BB2}$ and $c_{scene}$ are the signal counts recorded whilst observing them and $x$ is the proportional displacement of the scene radiance between the two black body radiances.

## Level 2 SST equation




SISTeR makes paired measurements of the sea and sky. Collecting terms:

$$L_{sea} = \rho\tau^2 L_{sky} + (1-\tau)(1+\rho\tau)B_{inst}(T_{air}) + (1-\rho)\tau\, SSB$$

After some rearrangement, the sea surface radiance $SSB$ can be written:

$$SSB = \frac{L_{sea} - \rho' L_{sky}}{1-\rho'} - kb_{air}$$

where:

| | |
|---|---|
| $\rho' = \rho\tau^2$ | effective sea surface reflectivity |
| $b_{air} = B_{inst}(T_{air}) - SSB$ | air radiance anomaly |
| $k = \frac{(1-\tau)(1+\rho\tau)}{1-\rho\tau^2}$ | air radiance sensitivity |

$SSB$ appears on both sides of the equation, but as the air temperature approximately tracks SST, this formulation gives smaller uncertainties when the air temperature is not known.

## Synthetic counts

In the level 2 sea surface radiance equation, measurements and uncertainties associated with the two black bodies BB1 and BB2 are common to both the calibrated sea radiance measurements $L_{sea}$ and the sky radiance measurements $L_{sky}$. Referring to the calibration equation, the sea surface radiance can be written explicitly as a function of the black body radiances and signal counts:

$$SSB = (1-x^*)L_{BB1} + x^* L_{BB2} - kb_{air}$$

where the proportional displacement $x^*$ between the black body radiances associated with the sea surface Planck radiance, is:

$$x^* = \frac{c^*_{SS} - c_{BB1}}{c_{BB2} - c_{BB1}}$$

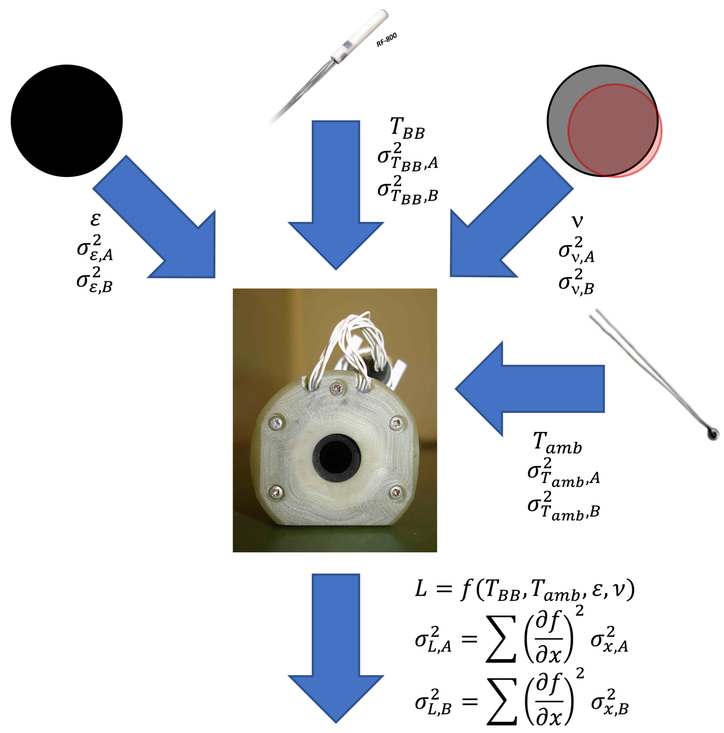
and the synthetic signal count $c^*_{SS}$ associated with the sea surface Planck radiance is:

$$c^*_{SS} = \frac{c_{sea} - \rho' c_{sky}}{1-\rho'}$$

where $c_{sea}$ is the signal count viewing the sea surface and $c_{sky}$ is the signal count viewing the sky.

## Uncertainties

Type A and Type B variances are propagated through all parts of the calibration and SST equations in parallel with base quantities, e.g. for each of the black bodies there are contributing terms from the cavity emissivity and temperature, vignetting and size-of-source effects and the ambient temperature of the instrument:




The processor is constructed from a hierarchy of similar small modules.

## ISRN and the L2R format

The International Shipborne Radiometer Network (ISRN) is a grouping of in-situ radiometer operators, including RAL Space, the University of Southampton and DMI, who are coordinating their activities to better support the validation of satellite SST products.

The group have agreed a common "L2R" data format for their level 2 SST products. The product is encoded in netCDF and closely follows GHRSST product norms.

The L2R data will be archived by Ifremer, who will also extract validation match-ups with the Felyx EO data tool.

www.shipborne-radiometer.org