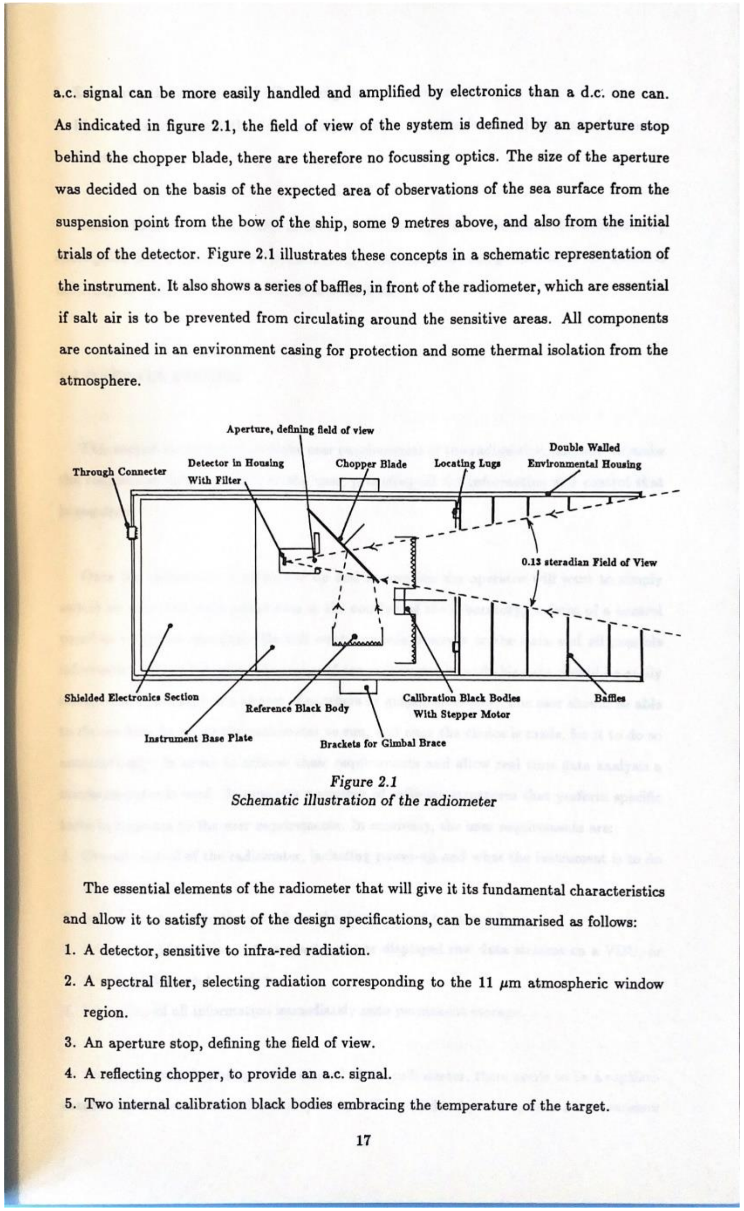
30 Years of SISTeR

Tim Nightingale and Arrow Lee

How SISTeR came to be

- Joined RAL in 1993 as "ATSR-2 Validation Scientist"
- Early days and the wild west of instrument development
  - Chris Hepplewhite's ROSSA radiometer (University of Oxford) – *picture to right*
  - Ian Barton's DAR-11 (CSIRO)
  - Peter Minnett's M-AERI (University of Miami)
- Invited instrumentation companies to propose designs
- Decided I'd have to build my own



a.c. signal can be more easily handled and amplified by electronics than a d.c. one can. As indicated in figure 2.1, the field of view of the system is defined by an aperture stop behind the chopper blade, there are therefore no focussing optics. The size of the aperture was decided on the basis of the expected area of observations of the sea surface from the suspension point from the bow of the ship, some 9 metres above, and also from the initial trials of the detector. Figure 2.1 illustrates these concepts in a schematic representation of the instrument. It also shows a series of baffles, in front of the radiometer, which are essential if salt air is to be prevented from circulating around the sensitive areas. All components are contained in an environment casing for protection and some thermal isolation from the atmosphere.

Figure 2.1
Schematic illustration of the radiometer

The essential elements of the radiometer that will give it its fundamental characteristics and allow it to satisfy most of the design specifications, can be summarised as follows:

1. A detector, sensitive to infra-red radiation.
2. A spectral filter, selecting radiation corresponding to the 11 μm atmospheric window region.
3. An aperture stop, defining the field of view.
4. A reflecting chopper, to provide an a.c. signal.
5. Two internal calibration black bodies embracing the temperature of the target.

17

A New Ship-Borne Infra-Red SST Radiometer

T.J. Nightingale

18/8/92

Introduction

A new generation of ship-borne infra-red radiometers are required to make validation measurements of sea surface temperature in support of the ATSR2 instrument, to be flown on ERS-2. With careful design, this instrument should also be capable of making other reseach measurements and may be of wider interest in the general field of oceanographic research.

A number of general (system) requirements and science requirements are set out below. At this early stage, these are intended more for guidance than as firm requirements. Comments are welcome.

General Requirements

Instrument to be a infra-red filter radiometer, carrying two principal calibration black bodies that operate at temperatures near the extremes of the anticipated SST range.

Instrument to be capable of taking sequential SST, sky brightness and calibration measurements without operator intervention.

Instrument to be tolerant of normal sea conditions, and to be capable of being sealed (though not necessarily whilst taking measurements) in poor sea conditions, preferably without operator intervention.

Instrument to be simple, compact, robust enough to withstand vigorous handling, and to contain the minimum of moving parts.

Instrument to be carefully baffled against stray light.

Instrument to be insensitive to external EM emissions (e.g. radio and RADAR) and to external power supply variations and noise.

Instrument to be modular where practicable, to possess an optical table of adequate size for future adaptation (e.g. Dewar and cooled detector, or additional channels), and mechanisms to be flexible in operation.

All analogue science and engineering data to be digitised within the instrument housing.

All mechanisms and registers containing instrument data to be adressable by an internal CPU (see below), capable of running control programs supplied by the operator. CPU to transmit data to a remote PC.

Instrument to be supported by a remote PC responsible for logging instrument data, generating real-time display screens, and issuing discrete operator commands and (compiled?) control programs to be run on the instrument CPU.

Science Requirements

NEdT	??mK	
Sea brightness temperature range	-260K to 310K	+/-100mK (1 sigma)
Sky brightness temperature range	-???K to ???K	+/-1K (1 sigma)
Ambient operating temperature	-50C to 50C	
Integration period	0.2s to 20s	
Chopping rate	25Hz to 250Hz	(NOT 50Hz or 60Hz)
Filter channels	(empty, 3.7, 8.8,) 10.8, 12.0um	
Aperture diameter	5 cm	
Cone angle	3 degrees	

Description of the New Design

The proposed instrument borrows some of the design features of both ATSR and ISAMS. Scanning is carried out by a plane mirror, canted at 45 degrees to its axis of rotation. The 360 degree scan range includes two black bodies at 30 degrees above and below the horizontal, so that a full 180 degree measurement range (vertically down to vertically up) is available.

Some protection and baffling for the scan mirror is provided by a simple wrap-round metal sheath. Baffling elsewhere in the foreoptics compartment is accomplished by a series of baffle plates with apertures slightly larger than the beam size.

A paraboloid mirror has its focus at the secondary a TGS detector. The beam is chopped by an ambient black chopper, mounted back-to-back with a filter wheel. The chopper/filter wheel housing is extended on the detector side to reduce contamination by scattered radiation. In effect it forms an intermediate black body cavity.

The chopper, filter wheel and detector, together with the scan mirror and black bodies, are fastened to an optical table. The electronics boxes are mounted on the underside of the table and adjacent to the paraboloid mirror.

Heaters and thermometers are provided at various points on the instrument. All heaters, thermometers, mechanisms and other registers can be controlled by the on-board microprocessor, either with a C program or by discrete commands sent by an external operator. The internal data bus is available both for diagnostic work, and for the control of an external calibration black body during testing. Communication with an external operator is by an asynchronous data link.

External Connections

External power supply	110V to 240V AC, 50/60Hz (switched mode PSU)
Data link	RS422 or fibre-optic
Buffered internal data bus (test only)	
Analogue detector and PSD outputs (test only)	

Data and I/O Requirements

All radiometer mechanisms/registers to be commandable/readable from an 8 bit internal parallel data bus.

Bus to be controlled by an 8 bit internal CPU.

CPU to support C.

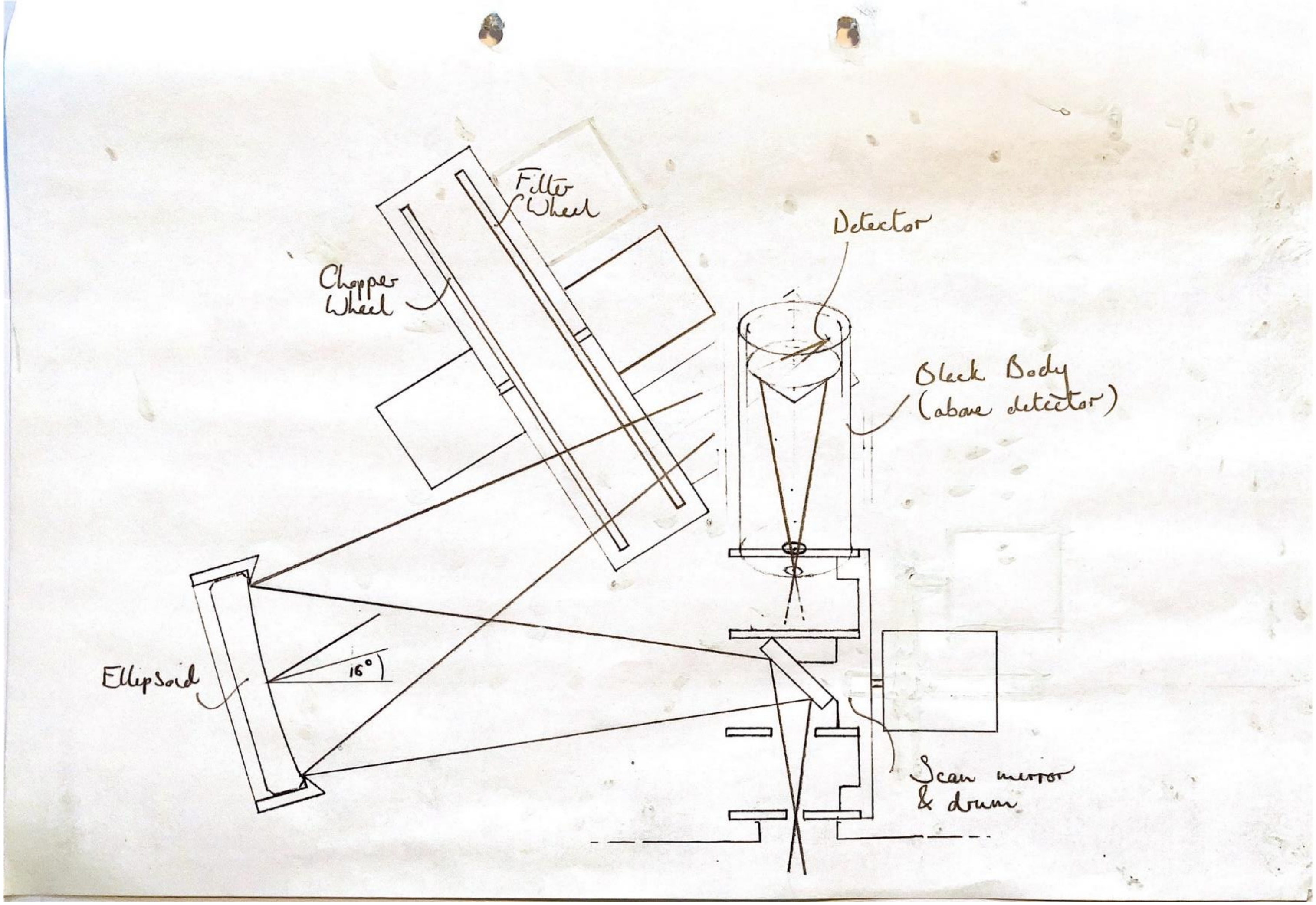
CPU to accept (compiled?) C programs over the data link.

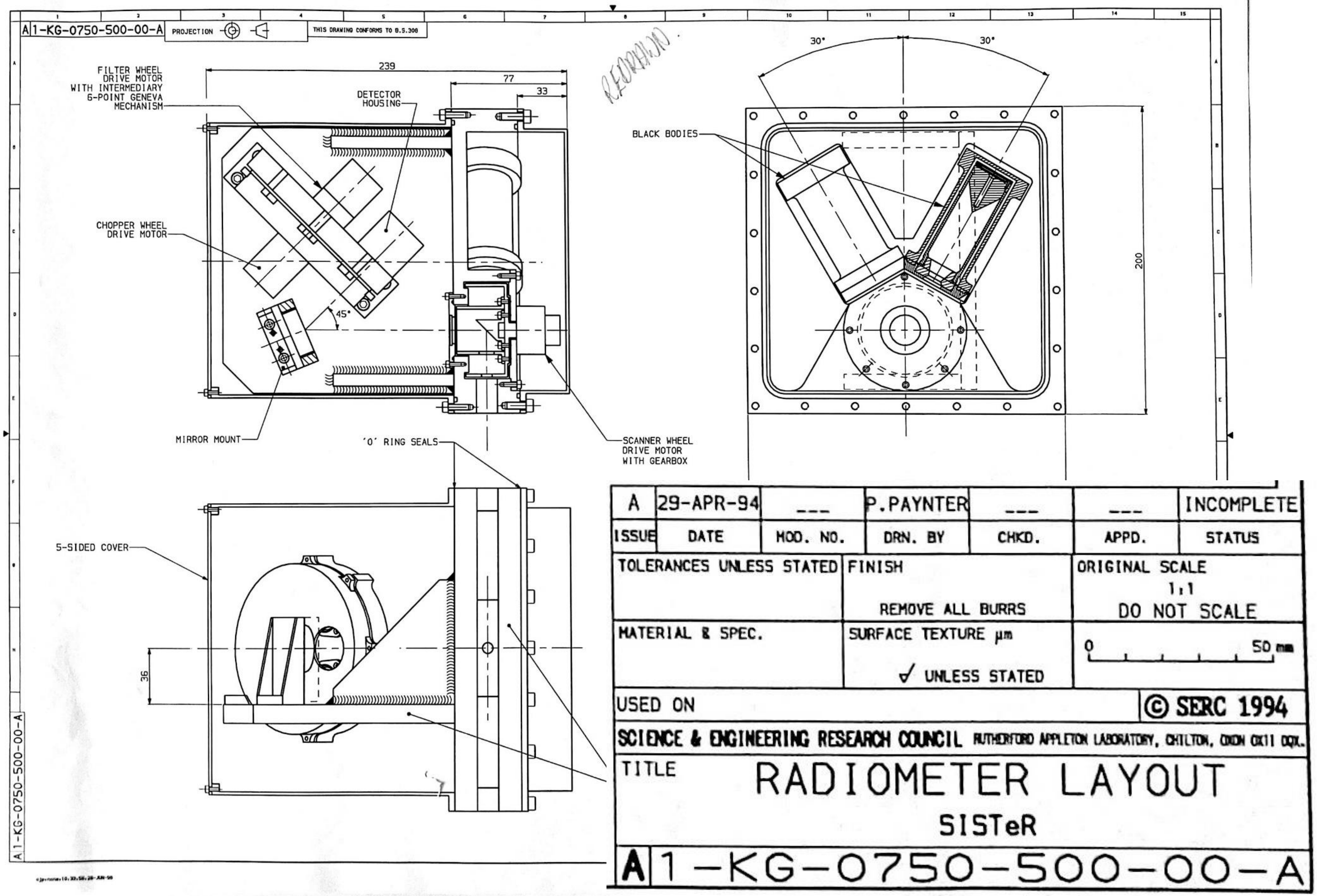
CPU to accept discrete commands over the data link.

CPU to transmit time-tagged data over the data link.

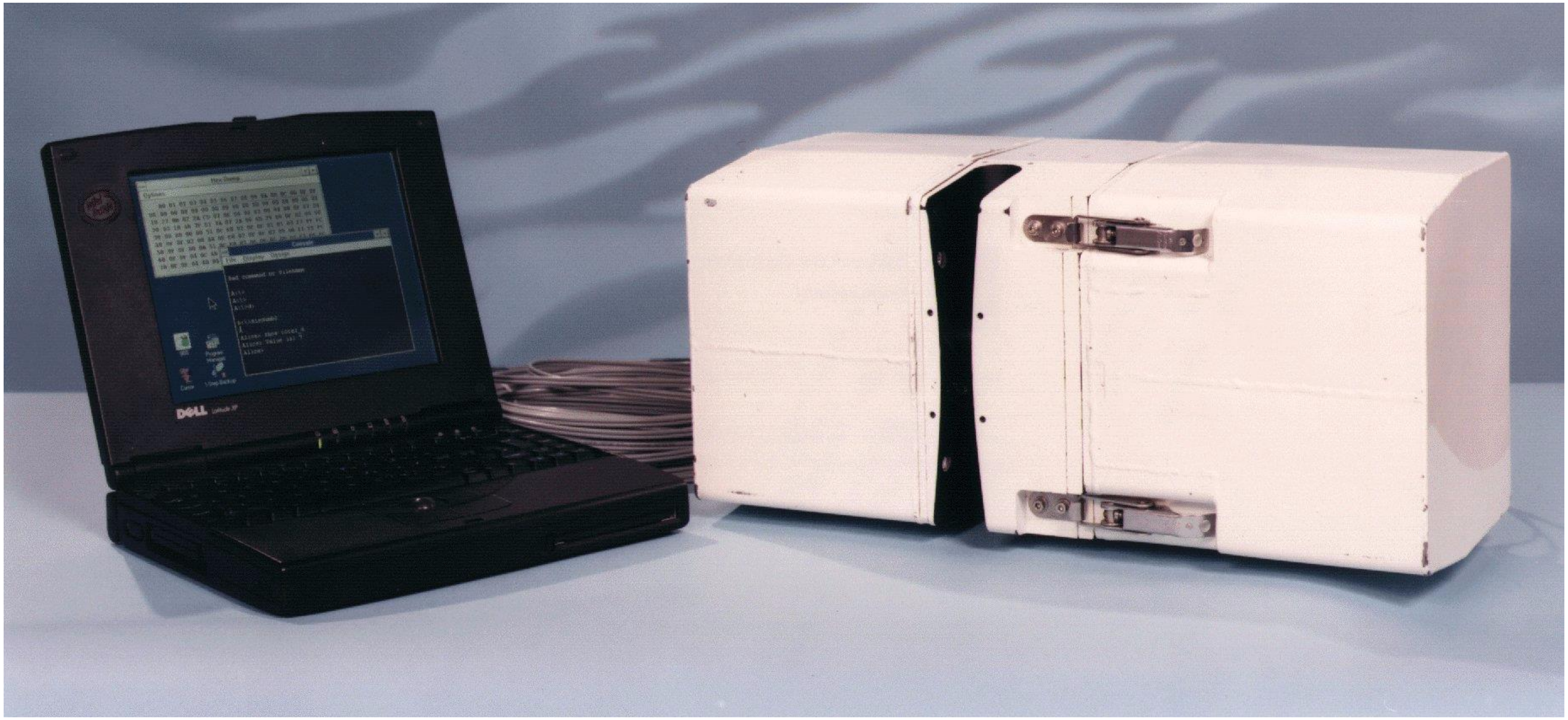
Data to consist of asyncronous time-tagged bit packets (time of data generation determined by CPU programs/timing tables).

Data packets to contain:
- identity tag
- data


Filter
Wheel
Chopper
Wheel
Detector
Black Body
(above detector)
Ellipsoid
15°
Scan mirror
& drum


A 1-KG-0750-500-00-A
PROJECTION
THIS DRAWING CONFORMS TO B.S.308
FILTER WHEEL DRIVE MOTOR WITH INTERMEDIARY 6-POINT GENEVA MECHANISM
DETECTOR HOUSING
239
77
33
CHOPPER WHEEL DRIVE MOTOR
45°
MIRROR MOUNT
'O' RING SEALS
SCANNER WHEEL DRIVE MOTOR WITH GEARBOX
BLACK BODIES
30°
30°
200
5-SIDED COVER
36
A
29-APR-94
P.PAYNTER
INCOMPLETE
ISSUE
DATE
MOD. NO.
DRN. BY
CHKD.
APPD.
STATUS
TOLERANCES UNLESS STATED
FINISH
REMOVE ALL BURRS
ORIGINAL SCALE
1:1
DO NOT SCALE
MATERIAL & SPEC.
SURFACE TEXTURE µm
✓ UNLESS STATED
0
50 mm
USED ON
© SERC 1994
SCIENCE & ENGINEERING RESEARCH COUNCIL RUTHERFORD APPLETON LABORATORY, CHILTON, OXON OX11 0QX.
TITLE
RADIOMETER LAYOUT
SISTeR
A 1-KG-0750-500-00-A

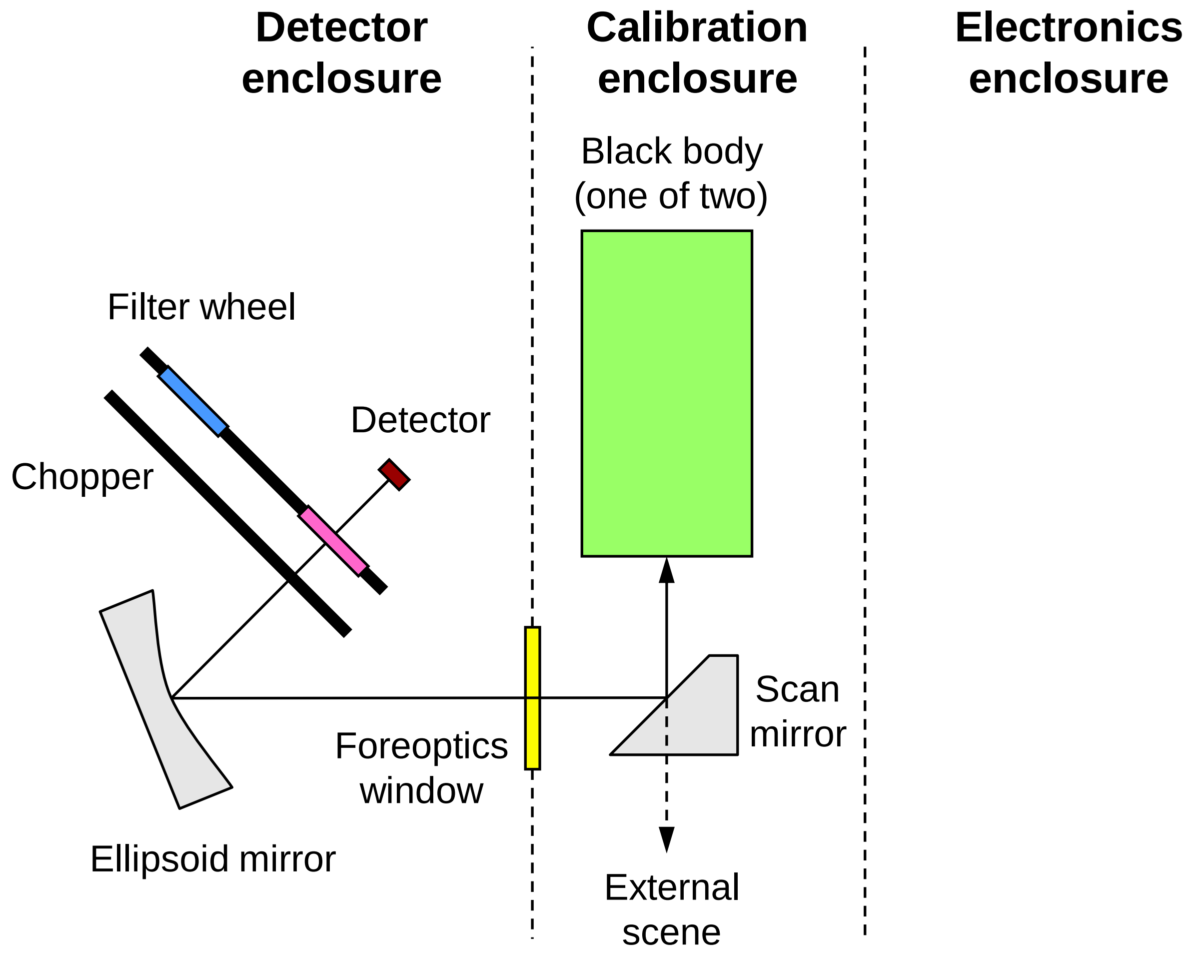
SISTeR



SISTeR description

- SISTeR (the Scanning Infrared Sea surface Temperature Radiometer) is a chopped, self-calibrating infrared filter radiometer
  - Capable of measuring infrared brightness temperatures to high accuracy, typically 30 mK or so
  - Black body thermometer calibrations traceable to ITS-90 (NPL)
  - Measurements taken with a 10.8 µm filter matching the (A)ATSR filter shape
  - Measures upwelling radiance from the sea surface and corrects for the reflected sky component with measurements of the downwelling sky radiance
  - Is autonomous – it can operate continuously without supervision and can protect itself against bad weather when required

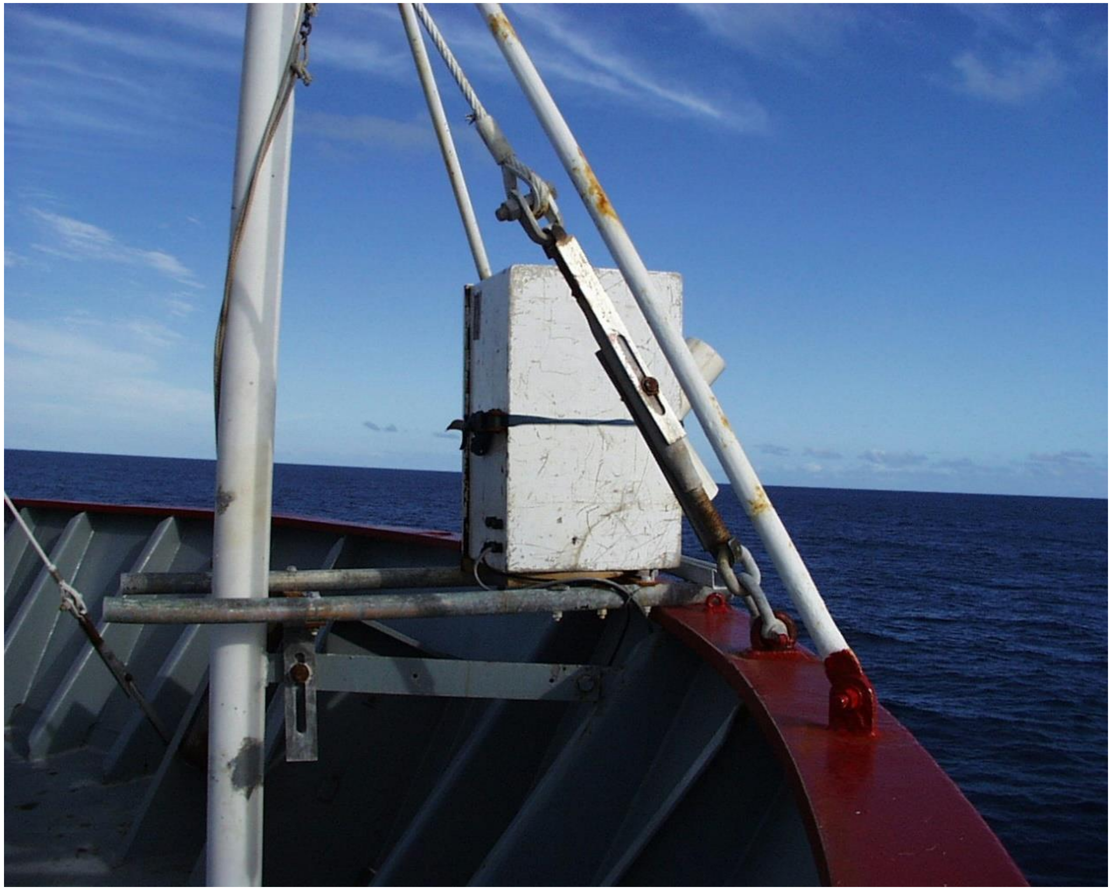
SISTeR layout



ROSSA96 (AMT 3)

The RRS James Clark Ross at Stanley, the Falkland Islands, October 1996

ROSSA98 (AMT 7) – the first ISAR?



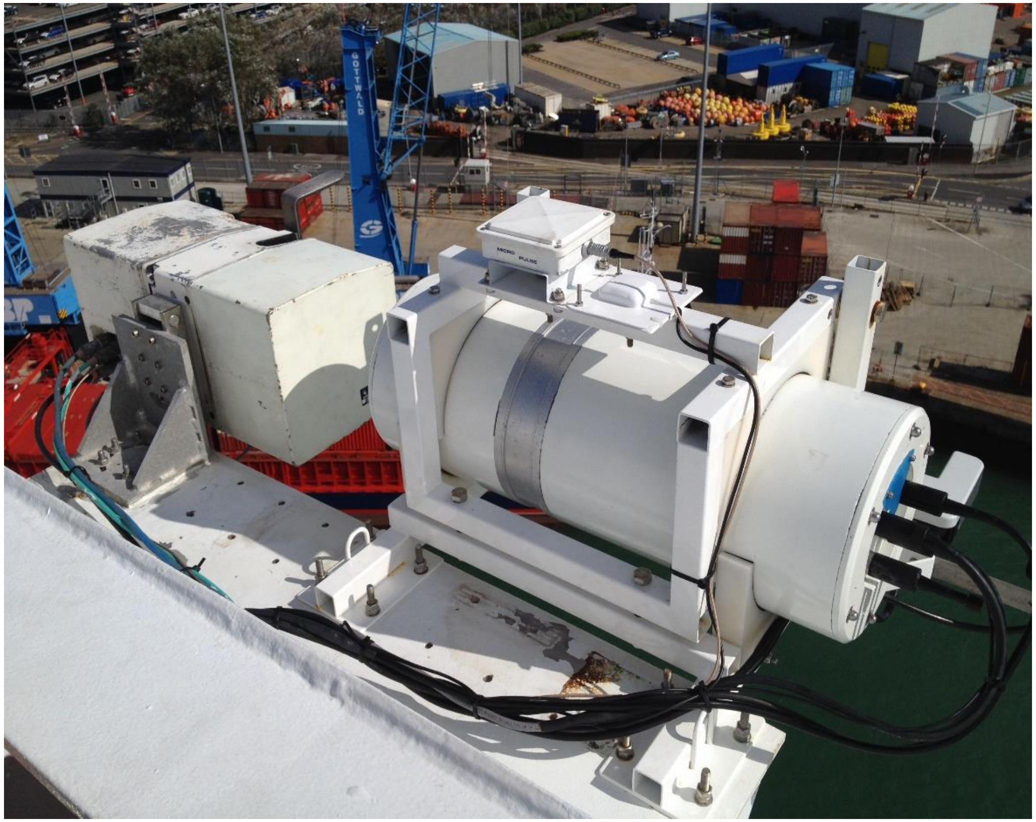
The RRS James Clark Ross in the South Atlantic, 1998

Ships

SISTeR on the Queen Mary 2

SISTeR on the Queen Mary 2

SISTeR / ISAR joint deployment

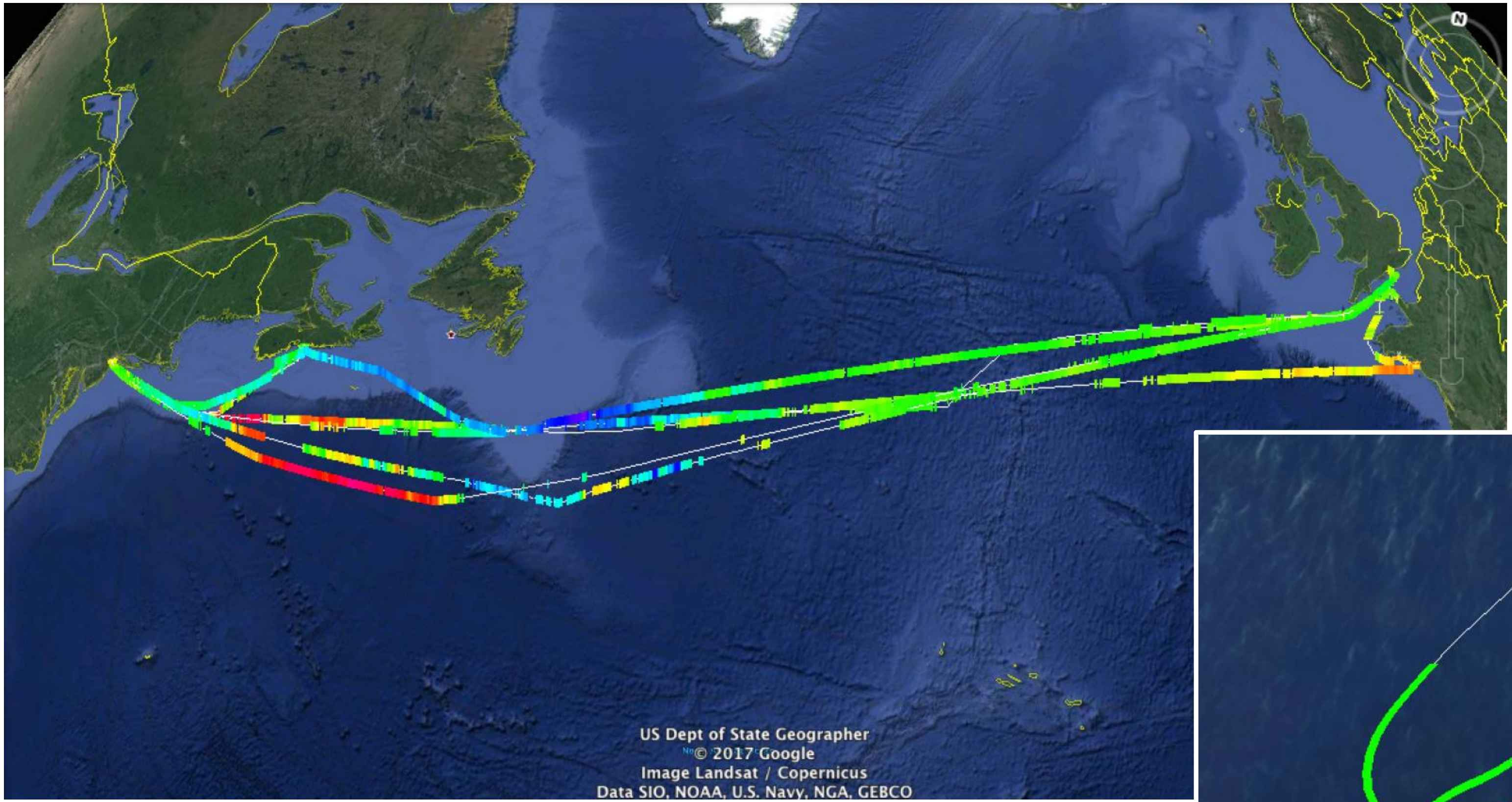


- SISTeR and the UoS ISAR jointly deployed on the QM2 in 2017
- Some teething problems, mostly associated with interactions between the SISTeR and ISAR rain gauges.
- Solved by repositioning the gauges and introducing an optical baffle between them

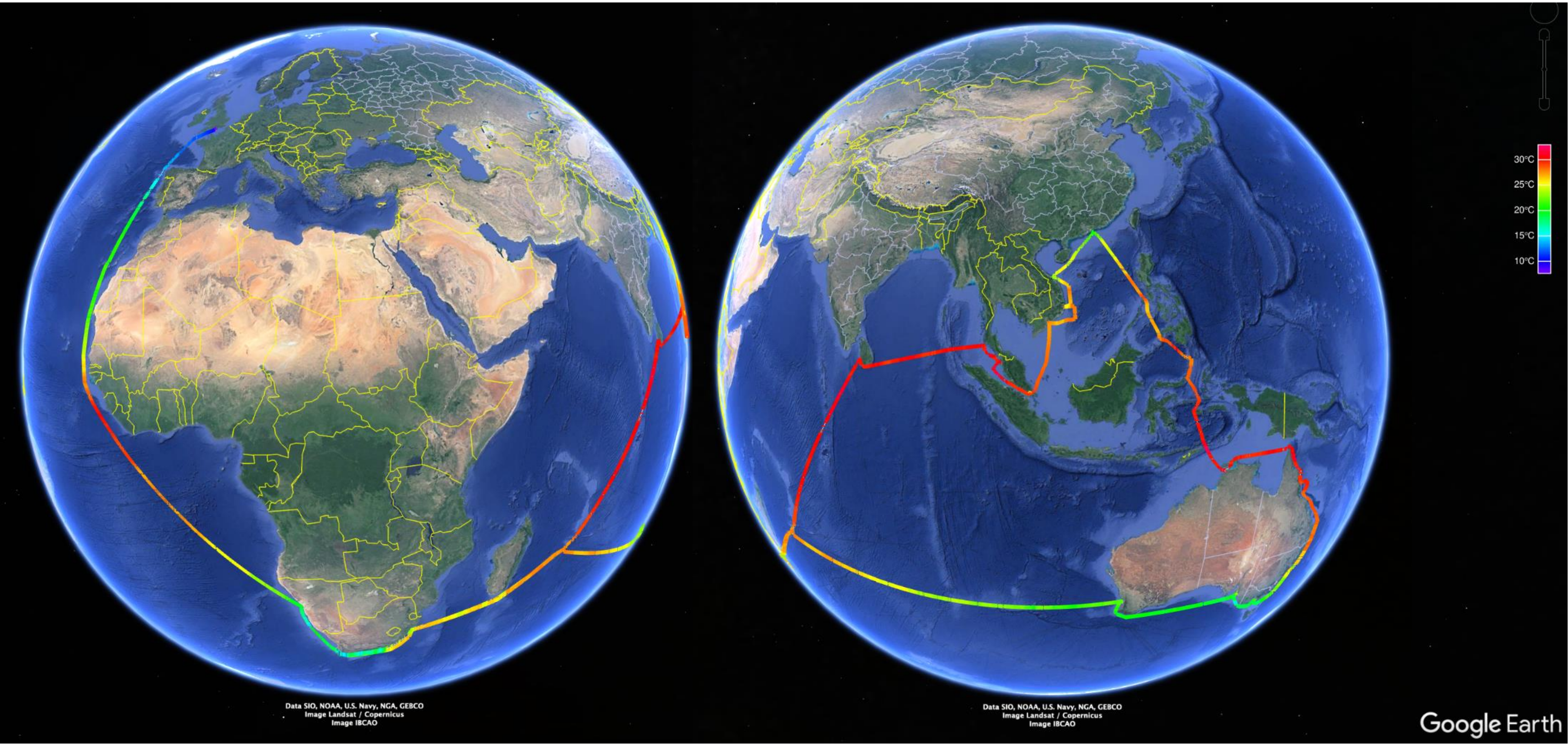
SISTeR on the Queen Mary 2

- SISTeR first deployed on the RMS Queen Mary 2 in 2010
- Main route is Southampton – New York
- Side trips to Scandinavia, Canada, Caribbean
- Annual “World Tour” each new year
- SISTeR is currently on her 27th QM2 cruise. Expected back at Southampton at the end of this week

Queen Mary 2 cruise 14 (2017)



Queen Mary 2 cruise 27



Thanks!

- To the funding bodies who have supported the (many) SISTeR deployments, particularly:
  - **NERC**, who have funded SISTeR in various forms over the years, currently through the **NCEO**'s service level agreement with RAL
  - **ESA**, whose contracts have funded SISTeR at different times almost from the beginning, and currently through the FRM4SST contract
- To the companies and institutions who have provided sea time on their ships, in particular:
  - **Carnival UK**, who have supported SISTeR deployments on the **Cunard Line** RMS Queen Mary 2 for fourteen years to date