

An overview of shipboard radiometers

Peter Minnett and Craig Donlon

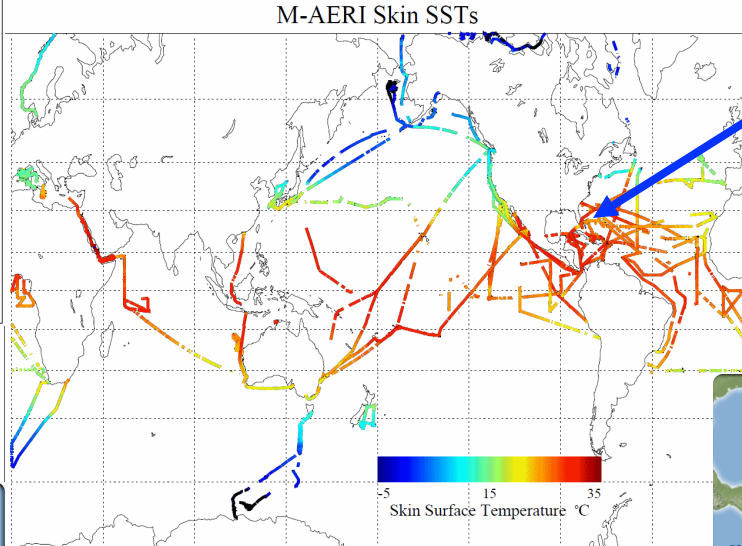
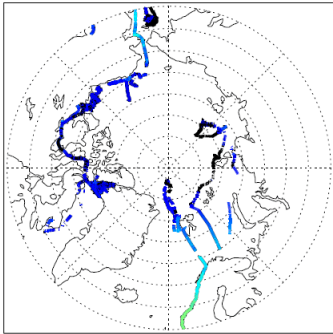
University of Miami and ESA-ESTEC

Name (date)	Spectral Definition	Passband (μm)	Detector type	Beam forming	Beam Steering	Calibration system	Comments	
PRT-5 (1970)	Filter	Single channel 9.5 – 11.5	Bolometer	Objective lens	Non (manual pointing)	Stirred water bath	Challenging to deploy used a water bath calibrator.	
RAL/SIL (1988)	Filter	Two channels 10 - 12	Pyroelectric	Gershun tube and parabolic mirror	Non (manual pointing)	Three internal black body cavities	No sky view unless radiometer manually pointed	
DAR-01I (1992)	Filter	One channel 10.5-11.5	Pyroelectric	Gershun tube and parabolic mirror	Non (manual pointing)	Three internal black body cavities	Sky view on opposite side from the sea view i.e. not at the most optimal θ	
SISTeR (1995)	Filter	Up to five channels 10.3 - 11.3	Pyroelectric	Off-axis ellipsoid mirror and steerable plane mirror	Programmable Plane rotating mirror	Two internal black body cavities	Research and autonomous deployment.	
MISTRC (1995)	Filter:	Four channels 3.728 (P) 4.025 (P) 10.75 11.78	HgCdTe	Objective lens	Non (manual pointing)	External stirred water bath	Very large experimental demonstration system.	
SOOSR (1998)	Filter	Single channel 8.0 – 12.0	TASCO THI-500L Thermopile	Ge AR lens	Non (manual pointing)	Two internal black body cavities	Low cost experimental demonstration system	
M-AERI (1996)	FTIR	3.0 – 18.0	Cooled HgCdTe, InSb	FTIR collimated	Programmable Plane rotating mirror	Two internal black body cavities	Large Advanced Research spectro-radiometer	
JPL-NNR (2002)	Filter	One channel			Non (manual	One internal black	No sky view, deployed	
ISAR (2004)	Filter	<p>From Donlon et al., <i>Ship borne Thermal Infrared Radiometer Systems</i>. Chapter 3.2 of <i>Optical Radiometry for Oceans Climate Measurements</i> (Elsevier Physical Sciences Series), 2014. In preparation.</p>						ditional to 3
CIRIMS (2005)	Filter							ystem
BESST (2013)	Filter							in

SST radiometers in routine use

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JPL-NNR (2002)	Filter	One channel 7.8 - 13.6	Thermopile	Ge lens	Non (manual pointing)	One internal black body cavity	No sky view, deployed on moorings
ISAR (2004)	Filter	One channel 9.6 - 11.5	Heitronics KT15.85D	Optical lens focused to diameter 6mm at 98mm	Programmable Plane rotating mirror	Two internal black body cavities	Autonomous operational deployment for up to 3 months
BESST (2013)	Filter	Three channel 10.8 12.0 8.0-12.0	320 X 256 pixel thermal imaging micro-bolometer	Ge objective lens	Programmable Plane rotating mirror	Two internal black body cavities	Lightweight design suitable for flight on drones

M-AERI cruises for MODIS, AATSR & AVHRR validation



Explorer of the Seas

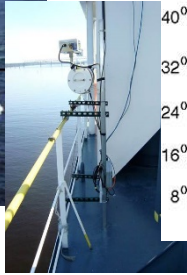


Fig 7. Mizzen, RSMAS-MPO. Sun Jul 22 16:33:01 2012. E:\msh\MAERI_skinSST-Tracks.ps

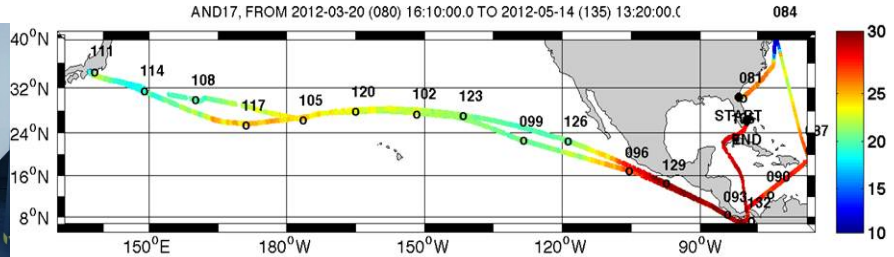
*Explorer of the Seas: near continuous operation
December 2000 – December 2007.*



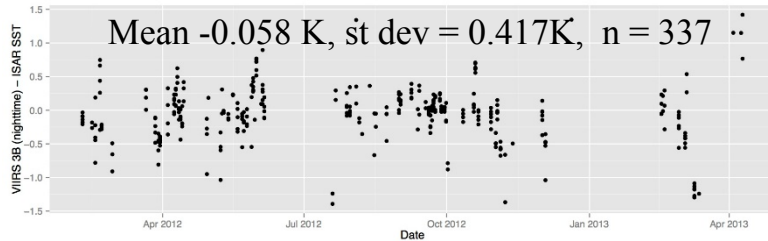
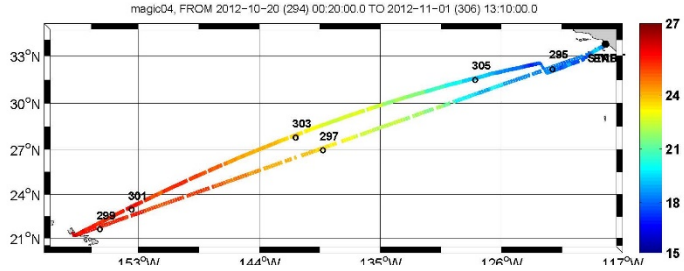
Ship radiometers: ISARs



*M/V Andromeda
Leader*



M/V Horizon Spirit



ISARs are autonomous filter radiometers with two internal blackbody calibration targets.

Pre- & post-deployment lab calibration against NIST-traceable calibrators.

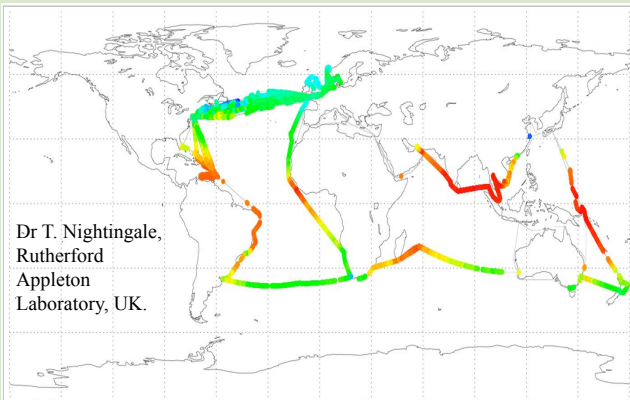
Data relayed in real-time by Iridium.

VIIRS v7.0 algorithm Reference SST WindSat 5day average.

Ship-board IR filter radiometers

Several groups deploy filter radiometers on ship for satellite SST validation. The European radiometers are supported by ESA for Envisat (past) and Sentinel-3 (future) validation.

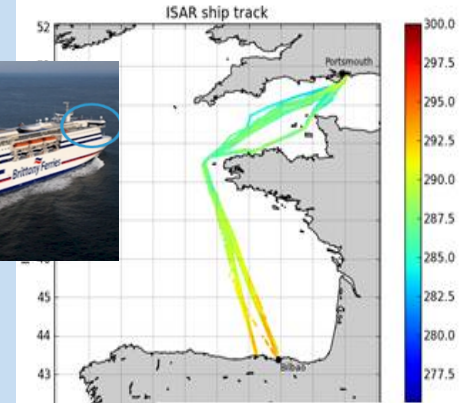
SISTeR (Scanning Infrared Sea Surface Temperature Radiometer) deployed by Rutherford Appleton Lab (UK) on Queen Mary II.



ISAR deployed by University of Southampton (UK) on Brittany Ferries



Dr W. Wimmer,
University of
Southampton, UK.



Within the framework of GHRSSST and ISSI Study Group, a consistent format for radiometer data and metadata is being defined to facilitate data exchange.

An archive is being identified – likely to be the British Oceanographic Data Centre.

SI-traceable calibration of ship-board radiometers

The NIST EOS TXR

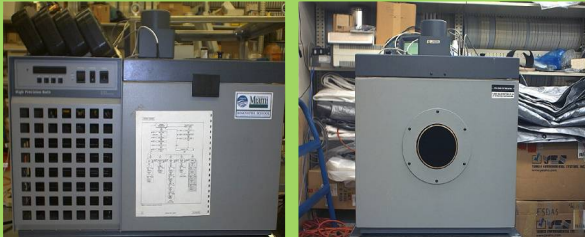


Unique EOS Standard
Cryogenic detectors (liquid N₂)
 $\lambda = 5 \text{ \& } 10 \mu\text{m}$

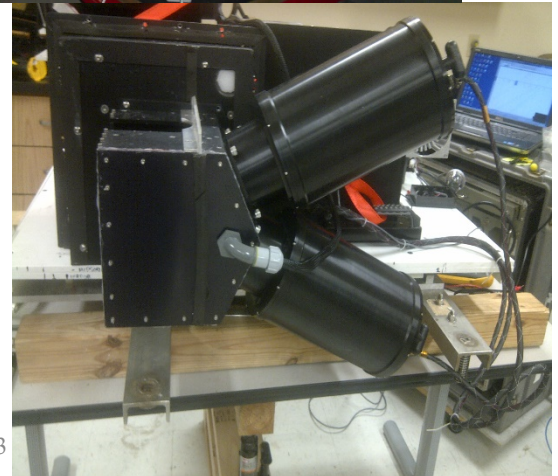
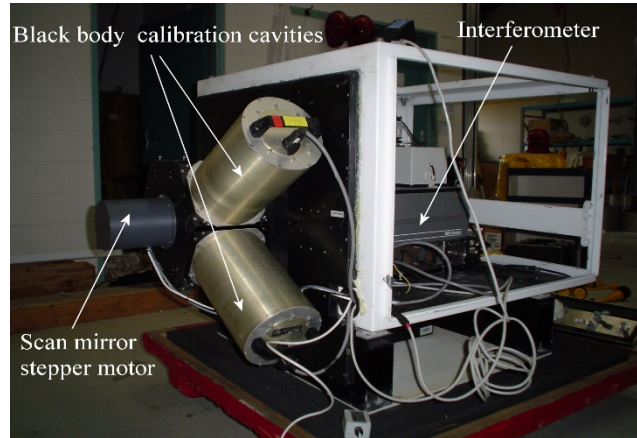
Rice, J. P. and B. G. Johnson, 1998, The NIST EOS Thermal-Infrared Transfer Radiometer, *Metrologia*, 35, 505-509.

Rice, J.P. et al., 2004, The Miami2001 Infrared Radiometer Calibration and Intercomparison: I. Laboratory Characterization of Blackbody Targets, *Journal of Atmospheric and Oceanic Technology*, 21, 258-267

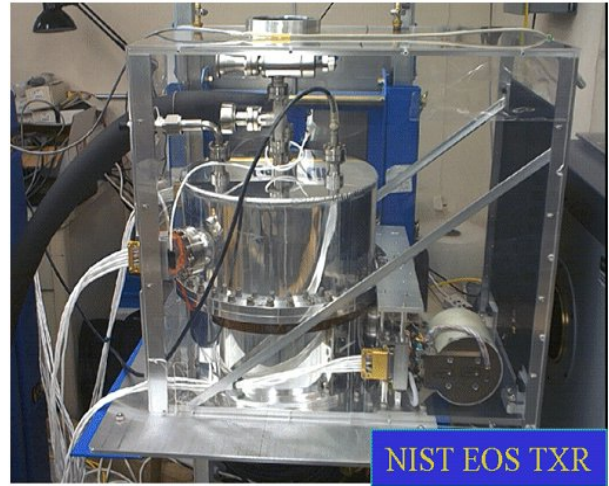
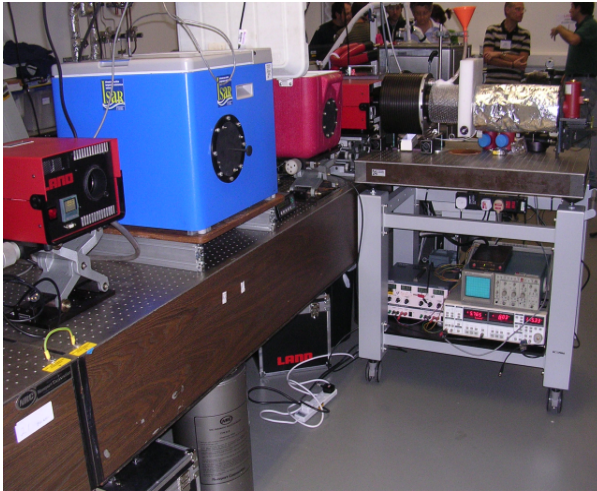
NIST water-bath black-body calibration target



See: Fowler, J. B., 1995. A third generation water bath based blackbody source, *J. Res. Natl. Inst. Stand. Technol*



SI-transfer standards



Laboratory blackbodies to assess the uncertainties in the ship-borne radiometer measurements pre- and post-launch calibration being compared to SI-standard references by AMBER at NPL (left) and by TXR at Miami (right).

Ship radiometer data format



Follow the Climate and
Forecast netCDF
conventions.
Implemented in netCDF 4.

Copies for comment
available from Tim
Nightingale

The Recommended GHRSSST L2i Data Specification

Version 1.0 Revision 2

Document Management	
Reference:	The Recommended GHRSSST L2i Data Specification v1.0 rev2.doc
Version:	1.0
Date of issue:	Thursday, 29 May 2014
Document type:	Microsoft Word [Compatibility Mode]
BookCaptain:	Tim Nightingale
Author:	ISSI <i>in situ</i> Radiometer Group
Master File Location:	Approved on-line version: TBD Development versions in: TBD

Content of Records

All L2i products should contain, at a minimum, the variables:

- Sea Surface Temperature data (**sea_surface_temperature**)
- Estimates of the total uncertainty in each SST sample (**sst_total_uncertainty**)
- Flags specific to each L2i data set that help users interpret data (**sst_flags**)
- A quality level for each measurement (**quality_level**)
- For radiometers, the viewing angle from nadir (**view_elevation**)

In addition, a number of auxiliary fields are recommended:

- An alternative time variable (**julian_day**)
- Estimates of the random uncertainty in each SST sample (**sst_random_uncertainty**)
- Estimates of the systematic uncertainty in each SST sample (**sst_systematic_uncertainty**)
- Measurements or estimates of the surface wind speed and direction (**wind_speed, wind_direction**)
- Measurements of the platform orientation and motion (**speed_over_ground, course_over_ground, speed_through_water, true_bearing**)
- Azimuthal orientation of the instrument view (**view_azimuth**)

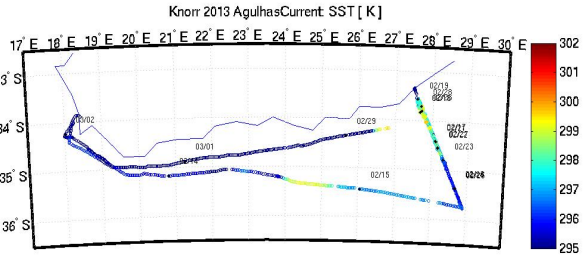
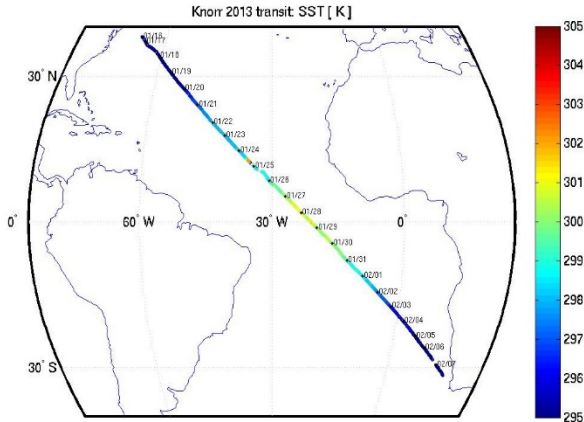
Repository

Likely to be British Oceanographic Data Center.

Suggestions for other centers welcomed.

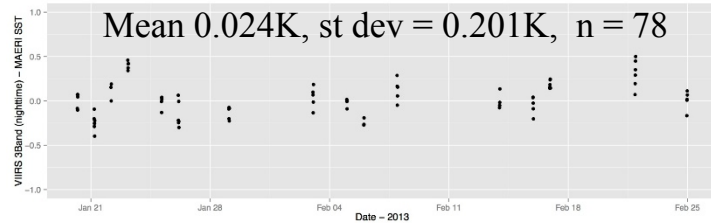
- Comments welcomed.

Ship radiometers: M-AERIs



Skin SST measurements from R/V *Knorr*. January – March 2013.

M-AERIs, new and old, on R/V *Knorr*. Transit from Woods Hole to Cape Town, and an Agulhas mooring recovery cruise.

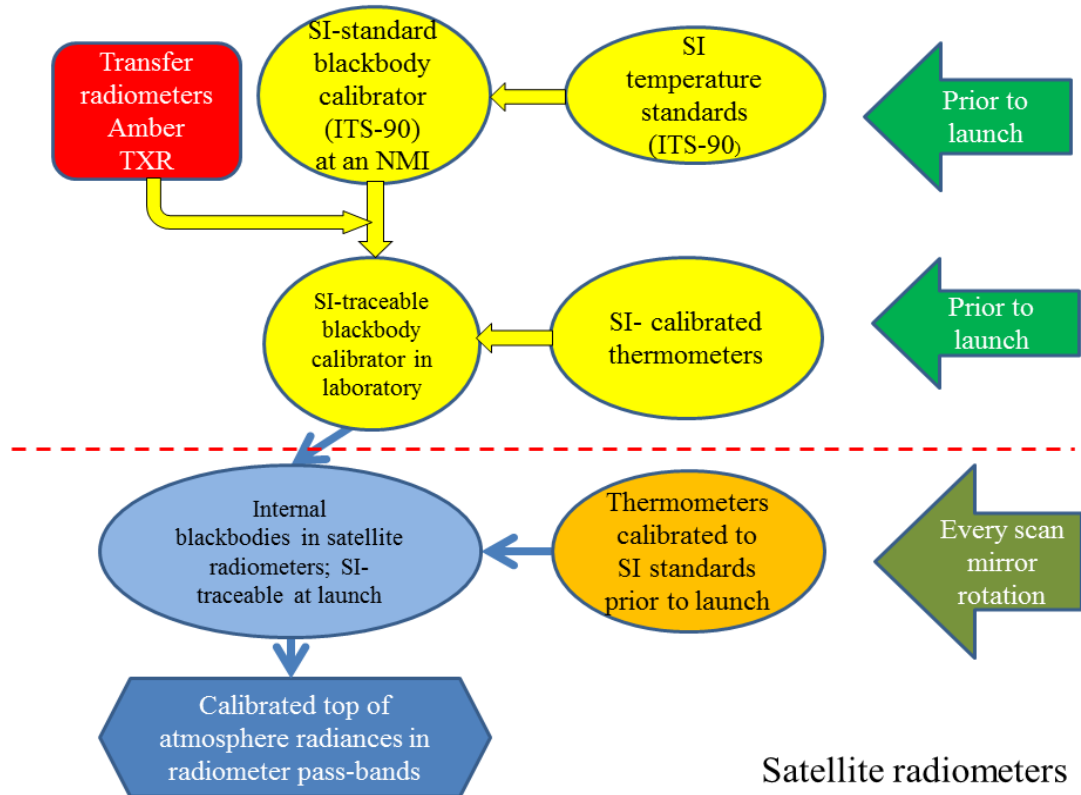


VIIRS v7.0 algorithm
Reference SST WindSat 5day average.

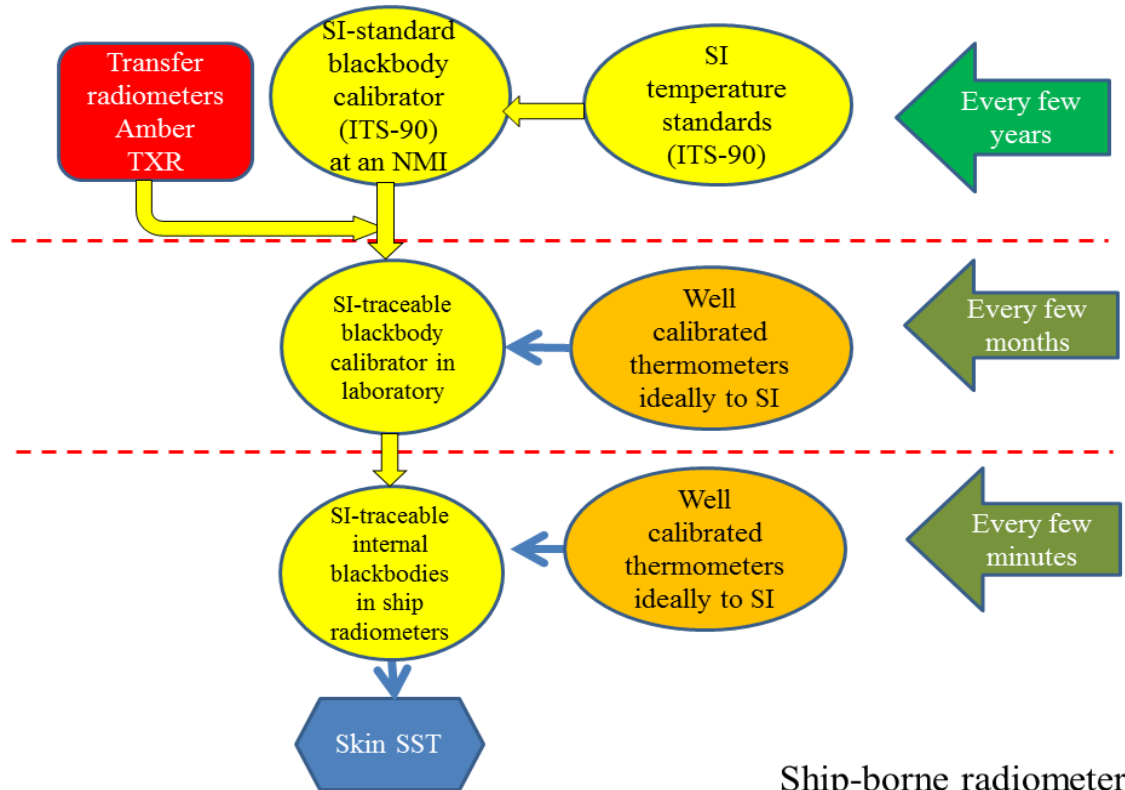
M-AERIs are Fourier Transform Infrared interferometers with two internal blackbody calibration targets.

Pre- & post-deployment lab calibration against NIST-traceable calibrators.

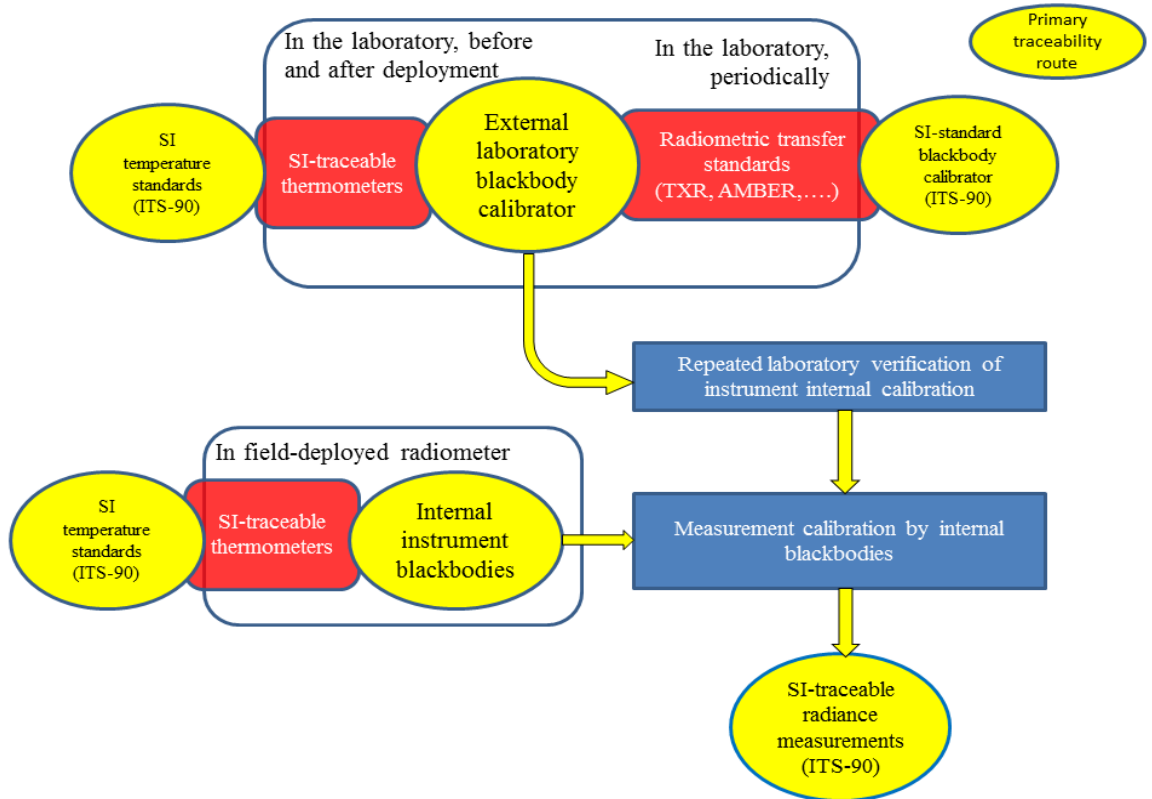
Calibrating satellite radiometers



Calibrating ship-board radiometers



SI-traceability of ship-board radiometers



Transfer SI-traceability to satellite retrievals

