PRE-LAUNCH CALIBRATION PROCEDURES AND THE ASSOCIATED TRACEABILITY ISSUES FOR EXISTING AND FUTURE INFRARED RADIOMETERS IN SPACE

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Infrared Sensors working in the wavelength range 3µm to 50µm measure radiation emitted from the Earth's surface and atmosphere. If the measurements are to provide quantitative information, for example sea-surface temperatures, then a fundamental requirement is to design a system that can be calibrated, such that any biases can be measured to a known accuracy either before launch or in-orbit. At IR wavelengths, calibration of the radiometric signals is normally achieved through on-board blackbody sources designed to give a known radiance. Ideally two sources, with high emissivity >0.999, accurate thermometry, good long term stability and spanning the expected range of scene temperatures, are used to provide an offset and gain measurement. A particular challenge for infrared sensors is the control of stray light sources due to self emission and great care is needed in the design to ensure that the on-board calibration can account for the instrument thermal background.

Achieving high radiometric accuracy and demonstrating traceability to standards is only possible if there is a rigorous pre-launch calibration program that includes: characterisation and calibration of the subsystems, a full instrument level test campaign under simulated orbital conditions and signals from ground calibration sources that are traceable to SI units. In this paper, the author will present the lessons learned from the pre-launch calibration activities of the Along-Track-Scanning-Radiometer (ATSR) series of instruments and the plans for the calibration of the Sea and Land Surface Temperature Radiometer (SLSTR) for ESA's Sentinel-3 mission as part of the GMES program.

The ATSR instruments are a series of space radiometers specifically designed to provide the information urgently needed for the debate on climate change and global warming, as well as to produce properly calibrated image data sets for use in a wide range of EO studies. These have been in operation since the early 1990s on ESA's ERS-1 and -2 satellites and the Advanced ATSR instrument (AATSR) is currently flying on the Envisat mission; each successive sensor has been an incremental improvement over the last. To meet its scientific goals, the instrument must measure radiances to an accuracy equivalent to a temperature error less than 0.1K for all pixels with radiometric noise must be less than 0.08K at 3.7µm and 0.05K at 11µm and 12µm, for a scene temperature of 270K. The pre-launch calibration tests were performed in a vacuum chamber with the instruments surrounded by temperature controlled panels to represent the thermal environment. Two blackbody sources originally provided by the UK meteorlogical office were used for the infrared radiometric calibrations of all three sensors. These sources were design to illuminate the full pupil of the instrument with an emissivity ~0.999 and known to < ± 0.0004 to give a worst case temperature uncertainty of ± 0.02K at 310K.

The blackbody thermometry was calibrated to an accuracy of ±0.01K traceable to ITS90 and had negligible self –heating to give an overall calibration accuracy of these targets were <0.04K. The paper will describe the test methods and procedures used for the calibration tests.

The SLSTR instrument is being designed to continue the Sea-surface temperature records produced by the ATSR series. The sensor includes the same spectral channels as its predecessor with the same radiometric performance, but will have a wider swath width (1400km for nadir, 800km for dual view) to give improved coverage, and higher spatial resolution (500m) for the visible to short wave infrared channels. Key to the success of the new instrument is to ensure that the calibration principles developed under ATSR are carried forward and improved upon.

It is planned to reuse the blackbodies from the previous three ATSR ground calibration campaigns to provide an important reference point between the series of ATSR instruments and the SLSTR calibrations. The radiances from the blackbody sources are derived from the temperature of the source via a radiometric model of the cavity. To validate the radiance model and ensure traceability of the radiance model it is necessary to compare the blackbodies against an external reference source. The paper describes the methods that are being pursued to provide the validation of the test equipment and improve the uncertainties involved in the calibration measurements.