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Chapter 5

Uncertainties in Radiance Calibrations

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Abstract

Three types of experiments were conducted to estimate the uncertainties in radiance calibrations using a plaque and FEL lamp: a) The average repeatability uncertainty (based on one plaque and one FEL used with 11 trials for three different radiometers) was less than 0.1% (0.06% in the blue–green part of the spectrum and 0.09% in the red); b) the uncertainty that can be removed from radiance calibrations if ambient rather than dark measurements are used was 0.13% (0.11% in the blue–green and 0.17% in the red); and c) the overall uncertainty from secondary reflections, (for example, originating from an alignment laser) was 0.11% (0.06% in the blue–green wavelength domain and 0.19% in the red).

5.1 INTRODUCTION

The calibration coefficient for a radiance sensor (identified by $S_{\rm ID}$) is computed using a plaque (identified by $T_{\rm ID}$) with a calibrated reflectance, $R^{\rm cal}_{T_{\rm ID}}$, plus a standard lamp (identified by $L_{\rm ID}$) with a calibrated irradiance, $E^{\rm cal}_{L_{\rm ID}}$. The general procedures require the lamp to be positioned a distance d on axis and normal to the center of the plaque (specific details for each step are given in Sect. 1.5). The radiance sensor is capped, and dark voltage levels for the sensor are recorded. An average dark level for each channel, $\bar{D}_{S_{\rm ID}}(\lambda)$, is calculated from the dark samples.

The radiance sensor is positioned to view the plaque at 45° with respect to the lamp illumination axis†. The lamp is powered on, and the voltage levels of the individual sensor channels are recorded, from which an average calibration voltage for each channel, $\bar{V}_{S_{\rm ID}}(\lambda)$, is obtained. The calibration coefficient is calculated as:

$$C^{\rm Rad}_{S_{\rm ID}}(\lambda) \;=\; \frac{\frac{1}{\pi}\,R^{\rm cal}_{T_{\rm ID}}(\lambda)\,E^{\rm cal}_{L_{\rm ID}}(\lambda,50)}{\bar{V}_{S_{\rm ID}}(\lambda)-\bar{D}_{S_{\rm ID}}(\lambda)}\left[\frac{50\ {\rm cm}}{d}\right]^2, \qquad (10)$$

where d is given in centimeters.

† An alternative angle for which the reflectance of the plaque is known is also acceptable, but for all of the SIRREX-7 experiments, 45° was the calibrated reflectance angle of the plaque and the corresponding sensor viewing angle.

Three types of experiments were conducted to explore the uncertainties associated with radiance calibrations: a) one plaque and one FEL were used with three OCR-200 radiometers to estimate the repeatability uncertainty in radiance calibrations (based on 11 trials for each sensor); b) three OCR-200 sensors and the SXR were used to explore the uncertainties in ambient versus dark measurements; and c) the uncertainty from secondary reflections used in the calibration process (in this case, an alignment laser) was measured with the SXR and three OCR-200 sensors.

5.2 RADIANCE REPEATABILITY

The uncertainties in radiance calibrations were estimated by independently calibrating three OCR-200 sensors (R035, R036, and R067) 11 times each (following the usual procedures). The trials were all with the same plaque and FEL, but the lamp was not powered on and off each time; it was left on to minimize lamp usage time (standard FEL lamps are too expensive to include the warm-up time for each trial in the experiment).

5.2.1 Equipment

The equipment used for the radiance repeatability trials was as follows:

- Satlantic Optronic lamp F-547 (L008);
- Satlantic white (18 in) plaque 05816 (T001);