Satellite Imager Calibration and Validation

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Abstract: The success or failure of any earth observation mission depends on the quality of its data. Data quality is assessed by determining the radiometric, spatial, spectral and geometric fidelity of the satellite sensor. The process is termed calval. This paper will describe calval techniques specific to South Africa.

1. Introduction

The success or failure of any earth observation mission depends on the quality of its data. To achieve optimum levels of reliability most sensors are calibrated pre-launch. However, the characteristics of the sensor may change during launch and when the satellite is on-orbit. Post-launch calibration is therefore essential for detecting any changes that occurred during launch and during the entire lifetime of the sensor while in-orbit. Some sensor designs incorporate onboard calibration instruments to facilitate post-launch characterisation. However, on-board calibrators are also susceptible to degradation over time. Therefore, post-launch calibration is made possible by taking in-situ measurements on the ground during satellite overpasses. The process of calibrating and validating satellite sensors post-launch is termed calval.

2. Methodology

Calval includes radiometric, spatial, geometric and spectral calibrations. The methodology for radiometric calibration includes the selection of suitable targets [1]. Then a model that relates the at-sensor radiance to digital numbers (DNs) for the selected target on the captured image is used to compute calibration coefficients as shown in equation 1.

$$CC_\lambda = \frac{DN_\lambda - O_\lambda}{L_\lambda} \quad , \qquad (1)$$

where CC_λ is the calibration coefficient, DN_λ is the average digital count of the sample site on the satellite image, L_λ is the at-sensor radiance and O_λ is the dark signal of the band situated at wavelength λ. O_λ can be obtained using various methods, including observing deep sea, dark space, or using camera shutters [2].

Spatial calibration of satellites is performed using long linear features or edged features of high contrast to compute the Modulation Transfer Function (MTF) [3].

One aspect of geometric calibration is done by comparing the coordinates observed on the satellite image and reference ground control points. The accuracy is then computed using the Root Mean Square Error (RMSE) [4].

$$RMSE = \sqrt{\frac{\sum_{ij=1}^{n} \left(X_i - X_j\right)^2}{n}} \quad , \qquad (2)$$

where X_i and X_j are the image coordinates and reference coordinates respectively and n is the sample size.

Post-launch spectral calibrations of multispectral sensors are a challenge. This is because one needs a uniform light source on the surface of the earth. A method using filtered lamps is currently under investigation.

3. Conclusions

Calval is a fairly new field of science. The characteristics of South Africa's SumbandilaSat will be validated based on existing methodologies well as with those that are still under investigation.

4. References

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