A METHODOLOGY TO ASSESS THE IMPACT OF OPTICAL AND ELECTRICAL CROSSTALK IN NEW GENERATION SENSORS USING HERITAGE DATA

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1. INTRODUCTION

Optical and electronic crosstalk in the Focal Plane Assemblies (FPAs) of satellite instruments degrades the radiometric quality of remote sensing data, and can be a major limitation to achieve performance quality needed for environmental and climate monitoring research. Correction algorithms for this effect have been developed, such as the one developed for MODIS short wave infrared (SWIR) bands using lunar data [1]. However, the crosstalk effect is a complex problem, and needs to be tested and corrected during the instrument design phase.

New generations of satellites are being designed for Earth Observation and are planned to be launched in the next decade. These new sensors will build upon experiences acquired from previous missions and will need to satisfy stringent data quality requirements, such as crosstalk,, to provide data necessary for long term climate change research [2, 3, 4].

Optical crosstalk has been shown to be dependent not only on the source wavelength, but also exhibits polarization and spatial dependencies (e.g. angular scatter). The new generations of environmental satellites will be required to develop a comprehensive definition of both optical and electronic crosstalk specifications, as well as reliable test procedures to collect appropriate data in the pre-launch phase. Crosstalk Influence Coefficients (ICs) derived from pre-launch spectral measurements form the foundation of the methodology described here to assess crosstalk impact on MODIS-like sensor radiances and associated geophysical algorithms. This analysis of crosstalk contaminated products will indicate potential problems and the necessity for a hardware fix and/or an on-orbit mitigation plan.

2. TEST SET-UP CONFIGURATION

A monochrometer source is used to illuminate a single band, which is comprised of an array of multiple detectors, and signals are collected on all other bands. Accurate alignment and width of the reticle used to illuminate each band is highly important to avoid leakages and spill-over not intrinsic to the sensor filters or optics.

A polarizer is used with the reticle to evaluate dependency of the crosstalk with polarized light. Collected test data describe the optical scatter from a sending band/detector into other receiving bands/detectors allowing a better evaluation of the sensor angular scatter with polarization. These data are used in the environmental product error budgets and can be used tosupport potential on-orbit mitigation approaches.

3. OPTICAL CROSSTALK DESCRIPTION

Optical crosstalk involves photons intended for one detector arriving somehow at another detector. Diffraction and scattering due to the sensor optics (or source for test equipment) upstream of the filter array (near field illumination) are not crosstalk, but rather are blurring or spreading mechanisms associated with image quality of the test equipment and some radiometric errors. Light directed from one detector to another through internal reflections in a filter substrate, reflections occurring between structural layers such as filters or lenslet substrates, or scatter in or after the optical filters are optical crosstalk mechanisms.

Various light scatter and crosstalk possibilities for both in band and out of band light being transmitted through the filters. Out of band light transmitted through the individual filters may show significant angular structure and might need to be characterized.

4. CROSSTALK IMPACT ASSESSMENT METHODOLOGY

The crosstalk performance assessment proposed here was tested for the bands of MODIS-like sensor . The crosstalk IC matrix generated was convolved with MODIS scenes to assess signals measured in the pre-launch phase to derive associated crosstalk radiance contamination. Artifacts, such as source near field response were filtered to ensure this component is not affecting crosstalk measurements.

The convolution between MODIS bands and the crosstalk coefficient is written as the following:

$$[L^*] = [M] * [S] * [L]$$

and

$$Xtalk = L^* - L$$

where L^* is the radiance matrix of all new sensor bands affected by crosstalk, L is the radiance matrix from MODIS bands, M is the new sensor sender-receiver crosstalk influence coefficients matrix, and S is the offset values for all bands measured for the new sensor (spacing between bands).

5. CONCLUSION

The paper describes an approach for optical and electronic crosstalk assessment based on an influence coefficients matrix that can be used during a new sensor development phase to assess crosstalk impact on radiance, environmental and climate products. The approach requires a robust test procedure and source characterization to mitigate uncertainties that might hamper the quality of the performance and impact assessments.

This approach was tested for the case of a new MODIS-like sensor. The convolution of the new sensor pre-launch crosstalk influence coefficients with scene data from MODIS bands provides a valuable test bed to assess crosstalk contamination in radiance and environmental products, in situations similar to those that will be observed on-orbit by a new sensor.

These assessments are valuable during the pre-launch phase and allow important decisions to be made early enough in the program. These include the addition or improvement of testing procedures to characterize or correct the crosstalk and hardware and/or algorithm improvements necessary to meet products performance requirements.

11. REFERENCES

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