AN OVERVIEW OF NASA NPP SDS-NICSE ACTIVITIES ON VIIRS SDR ASSESSMENT

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1. INTRODUCTION

The *NPP Instrument Calibration Support Element* (NICSE) is designed to assess the long-term geometric and radiometric performance of the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument. VIIRS is scheduled for flight on the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) mission. In making its assessment of VIIRS performance, NICSE directly supports NASA's goal of ensuring that VIIRS data is consistent with the long-term Earth Science Data Record (ESDR) that spans decades, and that includes data from multiple satellites and instruments.

The scientific and social imperative for long-term data records suitable for climate research has been defined by numerous U.S. national and international organizations. In the U.S., the National Research Council has repeatedly called for "an essential baseline of climate observations" [1, 2, 3]. Internationally, for example, the World Meteorological Organization has called for long-term, global observations of Essential Climate Variables (ECVs) to "provide the systematic and sustained observations needed by the World Climate Research Programme (WCRP) and the Intergovernmental Panel on Climate Change (IPCC)" [4]. The generation of long-term Climate Data Records (CDRs) is also one of the fundamental goals of the NPP and NPOESS [5].

NICSE promotes the generation of a well-calibrated VIIRS data set that can integrate into a long-term ESDR. In general, NICSE performs this process by establishing a quantitative understanding of the radiometric and geometric performance of the VIIRS data set. The details of this approach are provided below.

2. DESIGN OVERVIEW

The NICSE independently assesses the radiometric and geometric performance of the VIIRS Instrument

during the pre- and post-launch phases of the NPP Mission. The NICSE works with the SDS VIIRS Product Evaluation and Analysis Tools Elements (PEATEs) and the NPP Science Team (ST) to assess calibration algorithms or calibration Look-Up-Tables (LUTs), and develops recommendations for enhancements. These recommendations are tested, demonstrated, and validated with the VIIRS PEATEs and the SDS Integration and Test System Element (I&TSE). Recommendations are then submitted to the SDS Project Science Office (PSOE) for further review by the NASA NPP Project Scientist and the PSOE staff to confirm the scientific validity and significance of the recommended changes to the VIIRS calibration tables or product generation algorithms. If the recommended changes pass this level of review, they are recommended to the NPP Integrated Program Office (IPO) which will consider the changes for introduction into the NPP operational data production stream.

The NICSE's functionalities, interfaces, and data flows [5] are derived from SDS Level-3 requirements, designed to provide independent assessment that compliments but does not duplicate IPO and contractor activities. The NICSE is composed of the following subsystems: (1) The File Server Subsystem manages data, shares applications, and supports CM and issue tracking. (2) The Radiometric and Geometric Tools Subsystem is the collection of analytical software tools. (3) The Calibration Code Subsystem is the collection of vendor-supplied Science and Operational code for Sensor Data Record (SDR) generation. (4) The Radiometric and Geometric Developer/Analyst Subsystem updates analytical software tools , modifies the Calibration Code or LUTs, runs Calibration Code to apply modifications, and uses the analytical software tools to assess data and products.

3. NICSE INTERFACES AND DATA FLOWS

The NICSE interfaces with the SDS VIIRS Land PEATE, the SDS I&TSE, the SDS PSOE, the SDS Data Distribution and Depository Element (SD3E), NOAA CLASS Archive and Distribution Segment (ADS), and the NOAA Observing System Architecture (CasaNOSA). NICSE collaborates closely with the NPP Instrument Characterization Support Team (NICST), and these two teams merge after launch. NICSE also collaborates with the other SDS VIIRS PEATEs (Ocean and Atmosphere), and with the ST.

The NICSE obtains data and code from the Land PEATE, the I&TSE, the PSOE, the SD3E, ADS, and CasaNOSA. The Land PEATE is the NICSE's primary source for code and data. The NICSE receives requests for analyses and modified code and LUTs from the VIIRS PEATEs and the ST. The NICSE receives management direction from PSOE. The NICSE provides code and LUT changes and the results of analyses to the VIIRS PEATEs and the ST. The NICSE provides requests for test runs and data and/or code to the Land PEATE and I&TSE. The NICSE provides LUTs to the Land PEATE that are tailored to support production of consistent data sets for the Clouds and the Earth's Radiant Energy System (CERES) earth radiation budget research. The NICSE

provides reports and change recommendations to the PSOE.

4. SDR CODE, TOOL DEVELOPMENT, AND CALIBRATION VALIDATION ACTIVITES

The NICSE software consists of the Calibration Code Subsystem and the Radiometric and Geometric Tools Subsystem. The algorithms used in the calibration tools derived from those for the MODIS instrument, adapted to VIIRS instrument design and data structures. The MODIS Characterization Support Team (MCST) originally developed the methods and tools for MODIS on-orbit calibration and characterization [6]. It has produced multi-years of thermal emissive bands and reflective solar bands calibration and long-term trending for MODIS instrument onboard Terra and Aqua spacecrafts. These tools are written in C, FORTRAN, or IDL. The MODIS data assessment algorithms, experience, and lessons-learned [7] are being leveraged in developing the NPP/VIIRS diagnostic software tools.

The radiometric calibration tools include trending for detector calibration coefficients using on-board calibrators (OBCs), detector noise characterization and quality assurance, telemetry trending, and the radiometric stability using the Moon and Earth scenes. The geometric calibration tools include control point matching, error residual generation, residuals analysis/trending/correction, and geometric assesment tools. VIIRS geolocation error analysis tools are to provide means to find geolocation error in VIIRS and estimate corrections to geolocation parameters. From MODIS experience, initial error could be as much as 1km and we are hoping to reduce the error to less than 100m. The program uses aggregated I-band (imagery) geolocation and images. The error analysis cross-correlates landsat chip images (800m x 800m) with I1-images, and estimates along-scan and along-track shifts. From the residual errors, estimation programs produce corrections to the key parameters such as instrument coordinate system corrections, and estimate corrections to HAM wedge angles. These new sets of parameters will be used to improve VIIRS pointing accuracy along with orbit-by-orbit and seasonal analyses. In addition, the NICSE geo team will assess band-to-band image shift post-launch to validate pre-launch band-to-band registration (BBR) test results, including moderate-imagery band nesting.

The NICSE obtains NPP science and operational code and LUTs from CasaNOSA and the Land PEATE, under pre-launch Non-Disclosure Agreements. The code is installed on NICSE servers, and updated as available, to remain as close as possible to the current version in use for production of NPP operational products. NICSE uses the code for small-scale production of VIIRS SDRs from limited data sets, in order to assess the algorithms, products, and the effects of proposed changes to the code and LUTs.

5. STATUS, CURRENT ACTIVITIES, AND FUTURE WORK

NICSE has progressed through design and hardware deployment. NICSE is currently engaged in two

parallel activities: developing NICSE's software tools, and supporting assessment of VIIRS hardware testing. NICSE has deployed and networked our file servers, application servers, and development/assessment workstations across an internal/external NASA GSFC network. NICSE links to the internet to communicate with external sources and collaborators. NICSE has tested and verified all of our Level-3 interface requirements.

In order to support VIIRS pre-launch thermal vacuum testing, NICSE has completed development of 24 software tools, and has applied them to advise on the design of VIIRS testing, to assess test results, to indicate causes of peformance concerns, and to evaluate proposed solutions. This has included collaboration with and more than a dozen presentations and reports to joint NASA –IPO-contractor calibration teams. NICSE has planned the development of 32 assessment tools, tailored for VIIRS instrument design, products, and formats. These tools provide the functionalities necessary to fulfill NICSE's Level-2 assessment requirements. NICSE has tested and verified one quarter of our assessment tools, and is on-schedule to complete development of all tools at least 10 months before launch. This also represents completion of 20% of NICSE assessment requirements. The NICSE team has installed and run the last release of the NPP science code. The NICSE team has installed and run version 37 of the NPP operational code, which is one release behind the code currently being used to create NPP operational products. NICSE is currently migrating the next release of the operational code to our server. These tools and methodologies will evolve over the lifetime of the mission as instrument behaviors, changes, and degradation are characterized, understood and corrected.

6. REFERENCES

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