Title:

Development of the Second Generation Hyperspectral Airborne Tactical Instrument (HATI): HATI --II

Authors: S. Sandor-Leahy, S. Thordarson, B. Baldauf, M. Figueroa, M. Helmlinger, H. Miller, T. Reynolds, J. Shepanski

NORTHROP GRUMMAN AEROSPACE SYSTEMS, ONE SPACE PARK, REDONDO BEACH, CA 90278

Abstract:

The Hyperspectral Airborne Tactical Instrument-II (HATI-II) represents the latest in a long line of hyperspectral imagers (HSI) built at Northrop Grumman Aerospace Systems (NGAS), spanning the period from the late 1980's to the present.

The HATI-II system derives its heritage from both the NGAS HATI system and the Florida Environmental Research Institute's (FERI) SAMSON HSI system. The SAMSON system in turn derives its heritage from the ONR PHILLS and PHILLS-II HSI instruments, intended for use primarily in investigations of coastal phenomenon. NGAS acquired the SAMSON system mid-2009 and integrated portions of it into the HATI system. The resulting HATI-II system represents a flexible hardware configuration, which can be tailored to the needs of a given data collection campaign. In its full configuration it is comprised of a sensor head, electronics rack, optional stabilized camera mount and geolocation system, and optional mission logging audio-visual recording subsystem. The electronics rack hosts up to two ruggedized command, control and data storage computers, two flat panel displays, in-flight calibration related electronics and the audio-visual mission logbook recording subsystem.

The spectrometer sensor head consists of two physically separate spectrometer modules which use Offner grating spectrometers for dispersing light. To cover the full 380 to

2500 nanometer spectral range, one spectrometer covers the VNIR wavelength range (380 – 1000 nm), while the other spectrometer handles the SWIR portion of the solar spectrum (950 – 2500 nm). Each spectrometer module uses an imaging focal plane array (FPA) detector sensitive to the appropriate wavelengths of light; the VNIR spectrometer module uses a back-thinned silicon charge coupled device (CCD) FPA, while the SWIR spectrometer uses an Indium Antimonide (InSb) FPA cooled (80 K) with a closed-cycle mechanical cooler. FPAs used in the HATI system exhibit excellent quantum efficiency over the relevant spectral regions, particularly in the blue end of the visible spectrum, resulting in high signal to noise ratio (SNR) and noise equivalent signal radiance (NESR).

NGAS has a long history in the radiometric and spectral calibration of space borne and airborne instruments. Examples of systems calibrated by NGAS are ERBE (Earth's Radiation Budget Experiment), GeoLITE, 6 CERES (Clouds and the Earths Radiant Energy System) broadband radiometers, EO-1 Hyperion and Lewis HSI hyperspectral instruments, and all airborne HSI instruments mentioned previously. NGAS has set the standard for absolute radiometric accuracy in a space sensor in the CERES measurements: 1% in the 0.3 to 5μm shortwave channel, 0.5% in the 0.3 to > 50μm total channel, and 0.3% in the 8 to 12μm long wave window channel. These radiometric measurement accuracies are obtained using the NGAS Radiometric Calibration Facility (RCF). Hyperspectral sensors are calibrated in the Multi-Spectral Test Bed (MSTB) or Secondary MSTB facility. The HATI-II instrument is regularly re-calibrated in the Secondary MSTB facility before and after major data collection campaigns. The Secondary MSTB is a dedicated calibration facility for airborne sensors. An NGAS-developed mobile radiometric calibration unit (MRCU) enables calibration in the field during extended campaigns.

NG calibration expertise derives from prior radiometric and spectral calibration of space borne and airborne instruments (e.g., ERBE, GeoLite, CERES, EO-1 Hyperion, Lewis, TRWIS-III, HATI-I). The scientific value of hyperspectral data is directly related to sensor characterization and calibration accuracy, particularly focus (including spectral bandwidth, pixel purity, MTF, spectral smile and keystone), spectral channel assignment, radiometric accuracy, response linearity, NESR and source-dependent signal to noise. We use laser sources, gas lamps, broadband sources and the Air Force Bar Target for calibration, and the VNIR and SWIR instruments are spectrally calibrated using NIST-standards

HATI-II absolute radiometric calibration accuracy will be maintained via four methods: 1) pre- and post-campaign laboratory calibration, 2) an on-board calibration source, 3) pre- and post-flight runway calibration using same method as the laboratory calibration, and 4) vicarious calibration. The radiometric calibration (responsivity, linearity, saturation level, SNR) will be NIST-traceable. The absolute radiometric accuracy will be accurate to 5% (with a goal of 2%). HATI-II vicarious calibration will incorporate independent in-situ spectro-radiometric measurements at one calibration site per mapping region, using the spectral reflectance of spatially homogeneous, spectrally bright and flat tarps, soils and concrete slabs. This calibration will be used for verification of atmospheric correction. Targets will cover several image pixels to assure high accuracy comparisons. Concurrent in-situ sunphotometry and meteorological observations will provide inputs for the local radiative transfer model.

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