Extending the Satellite PMC Data Record with OMPS

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Ozone Mapping and Profiler Suite (OMPS)

- OMPS instruments are designed to continue long-term monitoring of ozone. Launched on Suomi National Polar-orbiting Partnership (NPP) satellite on 28 October 2011. All sensors use hyperspectral CCDs.
- Nadir Mapper (NM) measures total ozone using backscattered UV. 2800 km swath, 50 km x 50 km pixels (adjustable), spectral range = 300-380 nm.
- Nadir Profiler (NP) measures stratospheric profile ozone using backscattered UV. 250 km x 250 km footprint, spectral range = 250-310 nm.
- Limb Profiler (LP) measures profile ozone and aerosols using limb scattering in UV/VIS/IR. Altitude coverage = 0-80 km, spectral range = 290-1000 nm.

Nadir Profiler (NP)

- Designed to replicate SBUV/2 functionality (similar viewing geometry and spectral range) for measuring stratospheric ozone profiles.
- Hyperspectral measurements maintain ability to use legacy SBUV PMC detection algorithm, but also allows for testing of other options (e.g. use more or different wavelengths).
- Current results are consistent with concurrent NOAA-19 SBUV/2 data.
- Next NP instrument on JPSS-1 satellite (planned launch in early 2017) will conduct normal operations with 50 km x 50 km pixels within current footprint more ability to detect fine structure.
- NOAA plans to operate additional NP instruments through 2040, which would extend SBUV-type PMC record to 60+ years.

Overview of Measurements

- LP limb scattering measurements give snapshot of atmosphere over 0-80 km (Δx = 1 km) and 290-1000 nm (Δλ = 1-30 nm) every 19 seconds (~125 km separation between profiles).
- Three parallel slits look backward, oriented along-track and 4.25° (~250 km) to each side.
- Center slit observes same atmospheric region as NP instrument approximately 7 minutes later throughout every orbit Continuous "common volume" observations.

Operational Constraints

- Maximum altitude coverage varies between slits, along orbit, and during season. Southern Hemisphere measurements typically capture full PMC vertical extent, Northern Hemisphere measurements may not capture PMC peak (see examples below).
- Scattering angle covers large range along orbit (high in SH, low in NH). Ice phase function varies by factor of ~30 at UV wavelengths over LP observation range Observed PMC signal will vary substantially between hemispheres (similar to SME and SNOE).
- SH PMC analysis is affected by South Atlantic anomaly (SAA) effects on PMC vertical extent, Northern Hemisphere measurements typically capture full PMC peak (~250 km) and 290-1000 nm.

Characterization of PMCs in LP Data

- Current LP stray light correction is less accurate at high altitude, longer wavelengths Subtracting calculated radiance is problematic for quantitative analysis.
- Determine background by averaging non-cloud observed profiles at lower latitudes, normalizing to observed profile below PMC signal.
- Calculate difference to estimate strength of PMC signal.

Future Work (lots!)

- Create seasonal processing code for NP data and compare 2012-2015 results to NOAA-19 data.
- Incorporate OMPS NP data in long-term trend analysis.
- Evaluate changes in NP PMC detection results when different wavelength selections are used.
- Refine background determination and application for LP observations.
- Implement calculation of PMC peak intensity (parabolic fit?)
- Create seasonal processing code for LP data.
- Begin common volume studies.
- Note that LP instrument is not manifested on JPSS-1 satellite, but is planned for JPSS-2 satellite (launch ~2022).
Estimation of outgoing longwave radiation from Cross-track Infrared Sounder (CrIS) radiance measurements

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Abstract:
The purpose of this study is to provide real time CrIS-track Infrared Sounder (CrIS) Outgoing Longwave Radiation (OLR) using the hyperspectral infrared sounder radiance measurements. Atmospheric Infrared Sounder (AIRS) is used as the third transfer instrument, and the least-squares regression algorithm is applied to generate two sets of regression coefficient. One is between collocated Clouds and the Earth’s Radiant Energy System (CERES) OLR on Aqua and pseudo channel radiance calculated from AIRS radiance. The other regression equation is obtained by relating the pseudo channel radiance difference between AIRS and CrIS to the individual measured CrIS radiance in each pseudo channel, which is called adjustment coefficient. CrIS OLR is estimated as weighted linear combination of CrIS adjusted 17 pseudo channel radiances. We validate CrIS OLR by using very limited available CERES NPP OLR observations over 1°X1° global grids, and we also validate it against CERES (Aqua) OLR cases over the S-NPP and Aqua Simultaneous Nadir Overpass (SNO) observations. The results show that the precision of CrIS OLR estimation is within 3 W/m², and the accuracy is within 5 W/m².

Algorithm Description
In this work, we use broadband radiometer CERES OLR as truth, and AIRS as the third transfer instrument. Radiance adjustment regression database between AIRS and CrIS is derived with theoretical radiative transfer model simulations given ‘noaa88’ and ‘noaa89’ sounding collections for all sky conditions. Cloud conditions were simulated by ATOV derived cloud properties. Cloud is black except for cirrus which has spectral-dependent emissivity. We degrade AIRS, CrIS radiance spectra into 17 pseudo channels, and in each pseudo channel, the CrIS pseudo channel radiance is adjusted to AIRS pseudo channel radiances. Least squares regression algorithm is applied to relate CERES (Aqua) OLR to adjusted pseudo channel radiances calculated from CrIS radiances. Eight sets of regression coefficients are trained to account for view angle dependence of CrIS radiances. CrIS OLR is estimated directly as the weighted sum of pseudo channel radiance calculated from CrIS radiances.

Algorithm Validation

Simultaneous Nadir Overpass (SNO) observations comparison

Compare the estimated CrIS OLR with Aqua CERES OLR over the SNO observations. Take S-NPP and Aqua SNO observations from Jan. 2013 to Oct. 2013. Average samples for both CrIS and Aqua OLR within time difference less than 90 seconds, and distance difference less than 45 km; Single sample pairs with the smallest time and distance differences.

Summary
CrIS OLR was compared with simultaneous CERES NPP OLR directly over 1°X1° global grids. For CrIS homogeneous scenes, the results show that the standard deviation is within 5 w/m², and the bias is within 2 w/m². SNO OLR comparison shows that the standard deviation between CrIS OLR and Aqua OLR are within 5 W/m², and bias are less than 3 W/m².

References
SNPP ATMS and POES and MetOp AMSU/MHS take passive microwave (MW) measurements at certain high frequencies (88.2~190.31 GHz) that are sensitive to the scattering effect of snow particles and can be utilized to retrieve snowfall properties. An AMSU/MHS liquid equivalent snowfall rate (SFR) product has been produced operationally at NOAA/NESDIS since 2012. An ATMS SFR algorithm has been developed based on the AMSU/MHS SFR. The combined SFR products are generated from five satellites (NOAA-18/19, MetOp-A/-B, and SNPP), and can provide up to ten snowfall estimates at any location over global land at mid-latitudes. There are more estimates at higher latitudes.

Applications

The SFR products can be used to support weather forecasting

- fill in gaps where traditional snowfall data are not available to weather forecasters such as in mountains and remote regions where radar and weather stations are sparse or radar blockage and overshooting are common
- provide quantitative snowfall information to complement snowfall observations or estimations from other sources (stations, radar, GOES imagery data, etc.)
- to identify snowstorm extent and location of the maximum intensity within the storm
- Track storms and derive trending information (e.g., strengthening or weakening of the storm) by pairing with radar and/or GOES IR/VIS/WV images

Product Assessment

- NASA SPoRT led ATMS/AMSU SFR assessment in the 2014-2015 winter season. Several NWS Weather Forecast Offices (WFOs) from the Eastern Region, Front Range, Alaska and the NESDIS/Satellite Analysis Branch (SAB) participated in the evaluation.
- Direct Broadcast (DB) data from CIMSS at the University of Wisconsin and GINA at the University of Alaska Fairbanks were used to reduce product latency.

Cases and Feedback

Albuquerque, NM WFO (ABQ): The 919UTC image matched the NAM12 QPF forecast very well within a data void region. From this information I was able to determine the NAM forecast was too slow with the evolution of the precip...The radar values dropped off away from the KABX radar which is expected, whereas the SFR product increased in the area of heaviest snowfall. Rates were close to the observed value at KGUP. The NM DOT web page indicated difficult driving conditions within this region.

ATMS SFR Climatology

This study was partially supported by NOAA grant NA09NES4400006 (Cooperative Institute for Climate and Satellites -CICS) at the University of Maryland/ESSIC.
The role of the GCOS Reference Upper-air Network (GRUAN) in climate research

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Research in support of GRUAN operations
- It is imperative for GRUAN’s operations to be founded on research published in the peer-reviewer literature for scrutiny by the global community. Some examples:
  - Solar radiation-induced biases in radiosonde measurements have been assessed in Philipona et al. (2012).
  - Correction schemes developed for RS92 radiosonde data products have proven useful for developing correction methods for historical radiosonde data (Wang et al. 2013) and validating pre-flight corrections applied in the Vaisala ground-station software (Yu et al. 2015).
  - Whitman et al. (2011) investigated time to detect water vapour trends at ~200 hPa. Conclusion: at best it would take at least 12 years of daily observations at the Southern Great Plains site in northern Oklahoma.
  - Fassó et al. (2014) established statistical basis for understanding extent to which collocation uncertainty is related to environmental factors.
  - Madonna et al. (2014) provided criteria to quantify the value of complementary measurements and assess how measurement uncertainty is reduced by measurement complementarity.

What is GRUAN?
The Global Climate Observing System (GCOS) Reference Upper-Air Network (GRUAN) is an international observing network, designed to meet climate requirements and to fill a major void in the current global observing system by providing reference observations. GRUAN is envisaged as a network of 30-40 sites building, where possible, on existing observational networks and capabilities (Fig. 1 and 2).

GRUAN as part of a system of systems observing architecture

GRUAN RS92 radiosonde data product
- Tailored GRUAN data processing has been developed to correct temperature, pressure, humidity, and wind profiles for all known systematic biases and to generate vertically resolved estimates of the measurement random uncertainties (Dirksen et al. 2014).
- The dominant source of RS92 measurement errors is solar radiation, which causes temperature warm biases (partially compensated by ventilation) and humidity dry biases (Fig. 5).
- Corrections for radiation-related biases, and their uncertainties, are based on the results of experiments made at the GRUAN Lead Centre. Availability of the GRUAN RS92 radiosonde data product is shown in Fig. 4.

A GRUAN reference observation
- Is traceable to an SI unit or an accepted standard
- Provides a comprehensive uncertainty analysis
- Maintains all raw data
- Includes complete meta data description
- Is documented in accessible literature
- Is validated (e.g. by intercomparison or redundant observations)

Other products in development
- Water vapour profiles from high-resolution chilled-mirror frost point temperature measurements.
- Lidar measurements of temperature, ozone and water vapour profiles.
- Data products from FTS (Fourier Transform Spectroscopy) including water vapour, methane, carbon dioxide and ozone.
- Microwave radiometer (MWR) observations of temperature and water vapour profiles, total column water vapour and total cloud liquid water.

Getting involved in GRUAN
The primary point of contact is the Lead Centre through GRUAN.co@wde.de or GRUAN.chairs@wde.de.

Partners
- National contributors (fundamental to success of the enterprise)
- The Global Space-based Inter-calibration System (GSICS) and the Sustained, Coordinated Processing of Environmental Satellite Data for Climate Monitoring (SCOPE- CM) Initiative
- WMO; Its Commission for Instruments and Methods of Observations (CIMO); Commission on Climatology (CCI); Commission for Basic Systems (CBS); The World Climate Research Programme (WCRP)
- Existing observational networks (NDACC, ARM, GAW, ESRN, GUAN, GSN)

Literature

Figure 1: Current sites in GRUAN
Figure 2: GRUAN is intended to serve as a reference network which consists of well instrumented and well understood sites.

Figure 3: Schematic diagram showing some required measurements for a generic GRUAN site.

Figure 4: Availability of RS92 radiosonde data from across GRUAN. Each row for each site shows the data availability in 6 hour periods i.e. 00:00-06:00, 06:00-12:00, 12:00-18:00 and 18:00-24:00.

Figure 5: Contributions of the various uncertainty terms to the total uncertainty estimate of the GRUAN temperature correction for a specific sounding performed at Lindenberg on 27 September 2013 (from Dirksen et al., 2014). The total uncertainty is the geometric sum of the squared individual uncertainties. The correction model is the estimated vertically resolved error on the temperature based on the estimated actinic flux. This error is subtracted from the measured temperature profile to produce the corrected ambient temperature.

Figure 6: Total ventilation correction field over Lindenberg and surrounding region (from Dirksen et al., 2014).
Abstract: The Cross-track Infrared Sounder (CrIS) and Advanced Technology Microwave Sounder (ATMS) are two critical sounding sensors onboard the Suomi National Polar-orbiting Partnership (S-NPP) satellite. The NOAA Unique CrIS/ATMS Processing System (NUCAPS) is an infrared (IR) and microwave (MW) hybrid atmospheric profile retrieval system which uses collocated CrIS and ATMS measurements. The NUCAPS algorithm uses the Stand-alone AIRS Radiative Transfer Algorithm (SARTA) forward model for IR and MIT MW forward model for MW sounding to retrieve atmospheric vertical profiles of temperature, moisture, trace gases and other geophysical parameters. From the hardware aspect, due to the ATMS oversampling, the geolocation pointings of S-NPP IR and MW sensors are mismatched. Therefore, the NUCAPS preprocessor, in software aspect, does the critical function of CrIS/ATMS footprint collocation. The NUCAPS preprocessor is the module to match-up the two sensors of CrIS and ATMS. We proposed and implemented four versions of CrIS/ATMS footprint match-up methods in our offline test bed, namely: 1) CrIS FOR center matchup method (NOAA operational version) --- Select the single ATMS FOV which is closest to the center of each CrIS FOR and average it with the surrounding 8 ATMS FOVs. 2) CrIS FOV matchup method --- Select 9 single ATMS FOVs which are closest to each CrIS FOV respectively and average the selected 9 ATMS FOVs. 3) Backus-Gilbert (B-G) remapping method --- Select ATMS FOVs around a CrIS FOR and multiply them with pre-calculated B-G coefficients (per scan position and per ATMS channel) to obtain the effective brightness temperature as it is measured by a single microwave antenna with the antenna gain pattern that matches the effective CrIS FOR. 4) Improved CrIS FOV matchup method --- Select 9 single ATMS FOVs which are closest to each CrIS FOV respectively and average the selected 9 ATMS FOVs. Plus, apply the ATOVS and AVHRR Preprocessing Package (AAPP) package on ATMS channels 1, 2 to resize the beam width from 5.2 degrees to 3.3 degrees.

Descriptions of CrIS/ATMS Collocation Methods

1. CrIS FOR center match-up method

2. CrIS FOV matchup method

3. Backus-Gilbert (B-G) method

4. Improved CrIS FOV matchup method

Performance Assessment (granule samples in “red” area, 5/30/2013)

With Method 1

With Method 2

With Method 3

With Method 4

Summary

• All the four CrIS/ATMS match-up methods are computationally efficient enough to meet the real time operational requirements.
• The B-G method shows remarkable systematic corrections and positive impacts on the final retrieval products with an improved yield rate.
• We will focus on the B-G method improvements in the path forward and apply this method on the Joint Polar Satellite System (JPSS) series satellites.

Differences between the preprocessed ATMS brightness temperatures via different preprocessors (in one given scan line).

Performance Assessment

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References


Ongoing Monitoring and Validation of NOAA–Unique CrIS/ATMS Processing System (NUCAPS) Using NPROVS and its Expansion

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Introduction

The NOAA–Unique CrIS–ATMS Processing System (NUCAPS) was developed by the NOAA/NESDIS Center for Satellite Application and Research (STAR) and has been running operationally at the NOAA/NESDIS Office of Satellite and Product Operation (OSPO) since 2011. In this report, we present the ongoing activity of monitoring and validation of the NUCAPS IR+MW and MW-only temperature and water vapor retrievals using the NOAA Products Validation System (NPROVS) and its expansion (NPROVS+), which are supported by the NOAA Joint Polar Satellite System (JPSS) EDR data program.

The NUCAPS retrieval characteristics performance is analyzed using multiple reference datasets and compared with legal retrieval products. This validation is conducted in a variety of meteorological conditions and intensive cal/val campaigns and in terms of long-term variability and short-term time-averaging statistics.

NPROVS

NOAA Products Validation System (NPROVS)

Centralized RAOB and Satellite Product Collocation

NUCAPS retrieval characteristics performance is analyzed using multiple reference datasets and compared with legal retrieval products. This validation is conducted in a variety of meteorological conditions and intensive cal/val campaigns and in terms of long-term variability and short-term time-averaging statistics.

Short-term Monitoring/Analysis

a. MW temperature retrieval comparison: NUCAPS vs. S-NPP MiRS

NUCAPS MW retrieval mean bias (solid) and RMS difference (dotted) from RAOBs. The comparison is conducted for land and maritime conditions and intensive cal/val campaigns.

Continued

b. NUCAPS IR+MW in Intensive field cal/val campaigns

NUCAPS MW retrieval mean bias (solid) and RMS difference (dotted) from RAOBs. The comparison is conducted for land and maritime conditions and intensive cal/val campaigns.

c. AWIPS II Alaska Cold Core Event

NUCAPS MW retrieval mean bias (solid) and RMS difference (dotted) from RAOBs. The comparison is conducted for land and maritime conditions and intensive cal/val campaigns.

d. NUCAPS oper vs. test version

NUCAPS production test version is running at STAR. Among the improvements in the test version over the oper include using four days of ECMWF analysis data to generate regression coefficients for creating the IR first-guess and fixing some bugs in the retrieval processing code. The vertical statistics (bias and RMS) are computed using global data of July 15-26 2015. ECMWF and satellite retrieval temperatures are at around 200 hPa.

SUMMARY

This presentation demonstrates the unique capability of NPROVS and its expansion (NPROVS+) in routine monitoring and analysis of NUCAPS and other satellite products characteristics performance and in retrieval algorithm development activities.
NPROVS
The NOAA Products Validation System (NPROVS) was designed within the NOAA/NESDIS Office of Satellite Applications and Research (STAR) to compare, evaluate and monitor the performance of multiple satellite systems.

ProfileDisplay (PDISP)
Displays temperature and moisture profiles for the ground truth (RAOB) and every collocated processing system. All available raw data produced by each system and the associated ground truth can be viewed both graphically and as raw text.

Orbital Display System (ODS)
Graphical display of data from every product system used by NPROVS.

NPROVS Archive Statistics (NARCS)
Provides long-term trends of satellite minus baseline differences. Includes daily, weekly and monthly statistics of bias, standard deviation and rms.

Accessing And Running The Programs
All of the graphical programs are written in Java and can be run on a variety of operating systems including Macintosh OS X, Linux and Windows. For most people, accessing and running the programs is as simple as copying the program to a local computer and double-clicking the icon. More information about running the programs is available in the Quick Start Guide for each program.

Questions about NPROVS and specific requests for data access can be directed to Tony.Reale@noaa.gov

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References:
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Selected sounding footprints from a variety of satellites and other processing systems are collocated with ground truth data, typically radiosonde data, by locating a footprint that is closest to the ground truth in space and time. Once collocated, the system data can be compared to the ground truth and to other systems.

The collocated data can be accessed by anyone interested in characteristic performance of the satellite derived products. Daily, weekly and monthly collocation files are made available in binary and netCDF formats.

As part of NPROVS, a set of graphical programs was developed to allow users to view and compare the NPROVS data. The NPROVS Archive Statistics (NARCS) provides a long-term view of the performance of each system. ProfileDisplay (PDISP) shows individual collocation data and computes vertical accuracy statistics of temperature and moisture profiles. The Orbital Display System (ODS) shows images of associated orbital data.
Evaluating SNPP CrIS Spectral Noise from 2012 to 2015 with Allan Deviation

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Abstract
The Cross-track Infrared Sounder (CrIS) onboard the S-NPP (Suomi National Polar-orbiting Partnership) satellite has been running for about three and a half years. The spectral noise and response are analyzed in this presentation. The Allan deviation, which is effective in removing drifting trend in a time series, is used to calculate the spectral noise for each orbit. CrIS has three bands (LW/MW/SW). Each band has 9 field-of-views (FOVs) scanning in two directions. Four wavenumbers of each band are selected to show the temporal evolution: 650/720/830/1050 cm⁻¹ for LW, 1240/1375/1580/1710 cm⁻¹ for MW, 2150/2210/2355/2515 cm⁻¹ for SW.

It is found that the real part noise of the hot reference has almost no change since the beginning of the mission, indicating a sustainable stable sensor status. The imaginary part noise of the cold reference is very sensitive to the stability of the platform.

Method:
Step 1: Derive Gain of each orbit:

\[
\text{Gain} = \frac{\langle S_{\text{ICT}} \rangle - \langle S_{\text{DS}} \rangle}{\langle P_{\text{ICT}} \rangle}
\]

where S is the spectral count per scan; DS and ICT represent the cold and hot reference, respectively; P is the blackbody radiance; <> is the orbital average operator.

Step 2: Derive the radiance of reference target per scan:

\[
R_{\text{ICT}} = \frac{S_{\text{ICT}} - \langle S_{\text{DS}} \rangle}{\text{Gain}}
\]

\[
R_{\text{DS}} = \frac{S_{\text{DS}} - \langle S_{\text{DS}} \rangle}{\text{Gain}}
\]

where \( R_{\text{ICT}} \) and \( R_{\text{DS}} \) are complex value.

Step 3: Derive the NEDN with Allan deviation:

\[
\sigma_y^2(\tau) = \frac{1}{2} \left( \langle \tilde{y}_{n+1} - \tilde{y}_n \rangle^2 \right) = \frac{1}{2\tau^2} \left( \langle x_{n+2} - 2x_{n+1} + x_n \rangle \right)
\]

Conclusions:
The CrIS spectral noise is analyzed with Allan variance method. Most of the drifting effect is removed and it is found that CrIS sensors have very stable noise features in term of the hot reference, except the LW FOV1 which suffered a sudden jump of noise between July and Sept. of 2013, before returning back to normal status. All of the sensors, except the MW FOV7 which is known very noisy before launch, have much lower noise relative to the specification. The imaginary part noise of the cold reference, however, is sensitive to the shaking of the satellite platform, especially for the corner FOVs. ATMS main motor shaking in the late 2012 and the satellite orbital inclination angle adjustment on July 31, 2014 are two major events triggering the significant change of DS imaginary part noise.

The spectral response is also evaluated. It is found that the LW sensors have almost no degradation since the mission. The MW sensors have noticeable but different changes among difference sensors. All of the SW sensors have suffered a 2–3% degradation.
**Introduction**

The Advanced Himawari Imager (AHI) is the next-generation geostationary follow-on for the Japanese Meteorological Agency launched on October 7th, 2014. The instrument is a 16-band suite with 6 of the bands in the visible and near-infrared (VNIR) range. We use the matching moderate bands of the Visible Infrared Imaging Radiometer Suite (VIIRS) [1] to assess the multi-month radiometric response of the AHI VNIR bands from February to August, 2015 using deep convective clouds (DCC) near AHI sub-satellite point. To assess navigation accuracy we make imagery comparisons of landmarks, both visual and quantitative, against VIIRS. We also present a preliminary high-accuracy comparison analysis against the 30m-resolution Landsat 8 imageries to quantify sub-100m AHI navigation deviations.

**Co-Registration, Frame-to-Frame Registration and Navigation Accuracy**

The assessment of the AHI radiometric response against VIIRS is conducted at the single-pixel level, thus establishing both inter- and intra-bands pixel matching is necessary. Landmarks are used in examinations below.

**High-Resolution Navigation Analysis of AHI using Landsat 8**

A new effort has begun on the development of a high-accuracy quantitative analysis of AHI navigation accuracy using high-resolution Landsat 8 imageries (30m) to quantify low fractional-pixel deviations (<100m). The methodology is based on the NASA Geolocation Team's "landmark chips" approach. Recent preliminary result using Landsat 8 B4 against AHI B3 (red bands) demonstrates clear daily trends with deviations up to 1km.

**AHII-VIIRS Radiance Comparison Trend**

DCC pixels are identified by AHI B13 (10.35µm). The corresponding radiance of the AHI and VIIRS VNIR bands for the identified DCC pixels is compared at the individual pixels level. Each monthly update, up to mid-August, combines 7 days worth of data. The spectral band adjustment factor (SBAF) for the first 4 matching band pairs are directly obtained from the web-calculator based on SCHIAMACHY visible hyper-spectral data [3] and the SBAF for the bottom 2 matching band pairs is an estimation to within 1% accuracy.

**Summary**

- **AHI radiometric response versus VIIRS up to ±1% difference at 1.61µm**
- **Radiometric response monitor using DCC readied as operational tool**
- **AHI navigation deviations up to 1 km using VIIRS and Landsat 8**
- **Methodologies applicable to GOES-R Advanced Baseline Imager**

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**REFERENCES**


The NASA/NOAA Visible Infrared Imaging Radiometer Suite (VIIRS) instrument onboard the Suomi National Polar‐orbiting Partnership (SNPP) satellite was launched on 28 October 2011. VIIRS has 5 imagery resolution bands (bands I1 to I5) with 32 detectors each, 16 moderate amount of shift required for the best match between the image band pairs. Subpixel accuracy computed as follows:

\[
H(X) = -\sum p \log p
\]

where \( p \) is the probability density function (pdf) of image \( X \).

### Bicubic Interpolation

Our implementation of bicubic interpolation is based on K. Joy’s [4] summary description of the Catmull-Rom Splines [5]. A cubic curve can be represented parametrically by the polynomial function:

\[
P(t) = a_0 + a_1 t + a_2 t^2 + a_3 t^3
\]

that has the first derivative (slope):

\[
P'(t) = a_1 + 2a_2 t + 3a_3 t^2.
\]

An interpolated curve for \( t \) in the range of 0 to 1 can be specified by setting the values of \( P(0), P(1), P'(0) \) and \( P'(1) \) and solving the resulting system of equations:

\[
P(0) = a_0
\]
\[
P(1) = a_0 + a_1 + a_2 + a_3
\]
\[
P'(1) = a_1 + 2a_2 + 3a_3
\]

To fit an interpolative curve passing through \( n+1 \) control points \( P_0, P_1, \ldots, P_n \) we define the curve for the segment \( P_i \) to \( P_{i+1} \) by setting \( P(0) = P_i, P(1) = P_{i+1}, P'(0) = (P_{i+1} - P_i) / 2 \) and \( P'(1) = (P_{i+2} - P_{i+1}) / 2 \). Several algebraic steps lead to the following matrix equation for the interpolative curve \( P(t) \) for each line segment \( P_i \) to \( P_{i+1} \):

\[
P(t) = [1 t t^2 t^3] \begin{bmatrix} P_{0x} & P_{0y} & P_{1x} & P_{1y} \\ 0 & 1 & 2 & 3 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 2 & -5 & 4 & -1 \\ \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ a_2 \\ a_3 \\ \end{bmatrix}
\]

The above cubic interpolation for a single dimensional curve is extended to a two dimensional image by first performing the cubic interpolation along the column dimension and then applying it along the row dimension.

**References**


**Conclusions**

Our approach for on-orbit measurement of the BBR of pairs of VIIRS bands has produced results that are largely consistent with the pre-launch measurements with maximum BBR offsets on the order of 0.1 pixel (10%).
Suomi NPP VIIRS Detector Dependent Relative Spectral Response Variation Effects using Line-By-Line Radiative Transfer Model Calculations

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Abstract

The Visible Infrared Imaging Radiometer Suite (VIIRS) is a modern focal plane array based radiometer, which has many detectors with slightly different relative spectral response (RSR). Effect of RSR differences on imaginary artifacts, as well as geophysical retrieval uncertainties has not been well studied. Previous studies used the MODTRAN model for detector level radiative simulations. However, it is limited for the spectral resolution of the model relative to the narrow spectral bandwidth of the detectors. This study evaluates detector level RSR using Line-by-Line Radiative Transfer Model (LBLRTM) at higher spectral resolution 0.01 cm⁻¹ for VIIRS bands M15 and M16 under different atmospheric conditions. From the model simulation and case studies of VIIRS SDR brightness temperature data, we found that the shifting in imagery is most likely related to the difference between band averaged and detector level RSR, which has some atmospheric dependency. Cumulative histogram method is utilized to quantify the shifting. These findings will help S-NPP and JI to better understand the impact of the difference in detector-to-detector RSR on VIIRS geophysical retrieval and reduce the uncertainties.

Background

Previous studies have performed the possible causes for SST striping issue [Padula and Cao, 2015]. They used MODTRAN model to simulate the spectral radiances at the spectral resolution of 1 cm⁻¹ for five standard atmospheric profiles. Their results indicate that the SST product is likely affected by small differences in detector level - SRF, and the detector-to-differences have small atmospheric dependencies.

A study from SST EDR team [Dash and Ignatius, 2008] evaluated the biases in the top-of-atmosphere (TOA) brightness temperature (BT) model with MODTRAN model. They concluded that MODTRAN model does not reproduce spectral, angular, and water vapor dependencies with accuracies acceptable for SST analyses. Therefore, in this study, we use LBLRTM with higher resolution to investigate the SST striping issue.

VIIRS Daytime SST Algorithm & Imagery Analysis

The daytime VIIRS SST is computed from a non-linear split window algorithm using the brightness temperatures from bands M15 and M16:

\[
\text{SST} = a_1 + a_2 \text{BT}_{15} + a_3 \text{BT}_{16} + a_4 \text{BT}_{15}^2 + a_5 \text{BT}_{16}^2 + a_6 \text{BT}_{15} \cdot \text{BT}_{16} \tag{1}
\]

where \(T_{15}\) and \(T_{16}\) are the brightness temperatures at M15 (15.3um) and M16 (12.0um), respectively. \(a_i\) is the first guess SST from either numerical weather prediction or analysis fields. \(a_i, a_2, a_3, a_4\) and \(a_5, a_6\) are the coefficients derived from the regression process.

VIIRS SST EDR group found an anomalous stripping pattern in daytime SST product, and they developed an algorithm to improve the quality of the SST product. They confirmed that the need to analyze the stripping at the SDR or L1B level to reduce the propagation of any system artifacts to SST product. Figure 1 shows stripping at SDR brightness temperature.

![Figure 1. Suomi NPP VIIRS SST brightness temperature product in M15-M16 over the bay of Bengal on July 3, 2014. (Left): Subset of SDR BT for a uniform ocean surface under clear sky condition.](image)

Line-by-Line Radiative Transfer Model

LBLRTM [Clough et al. 1998] is an accurate and efficient line-by-line radiative transfer model which provides spectral radiance calculations with accuracies consistent with the measurements [Clough et al. 2004]. LBLRTM 12 is used in this study to simulate the TOA spectral radiance under six standard LBLRTM atmospheric profiles.

The output spectral radiance is then convolved with VIIRS relative spectral response (RSR) to get the channel effective radiance:

\[
\text{L}_{\text{eff, \text{channel}}} = \int_0^{1000} \frac{L_{\text{channel}}(\lambda) \cdot R(\lambda)}{A(\lambda)} \, d\lambda
\]

where \(L\) is the at sensor radiance and \(R\) is the RSR of a given band. The simulated effective radiance for each band \((L_{\text{eff}})\) was converted to BT \((T_{\text{eff}})\) using the numerical method by minimizing the difference between BB radiance and channel effective radiance.

Data Collection and Analysis

In this study, we will check the difference in effective brightness temperature \((\Delta T_{\text{eff}})\) between using the detector level BT and the band averaged BT using Equation: \(\Delta T_{\text{eff}} = T_{\text{eff, \text{detector}}} - T_{\text{eff, \text{averaged}}}\) (2)

Where \(T_{\text{eff, \text{detector}}}\) is the effective brightness temperature computed using the detector level RSR and BT and \(T_{\text{eff, \text{averaged}}}\) is the effective temperature computed using the band averaged RSR.

Figure 2 shows the effective brightness temperature differences between the detector-level band and band averaged SST in VIIRS M15 (Top left), M16 (Top right), and M15 – M16 (Bottom) from the LBLRTM radiative output for six atmospheres. Results indicate that there is a small but obvious atmospheric dependency. The odd/even detector pattern is also observed. In M15, the smallest BT difference is at 0.01K, which is almost constant for both BT and BT - M16. Therefore, it is not the dominant factor. In M16, the largest BT difference is at 0.02K, which is smaller for BT than BT - M16. However, in the band BT - M16, the difference is larger for BT than BT - M16. It has been identified that the smallest BT difference is at 0.01K, which is almost constant for both BT and BT - M16. Therefore, it is not the dominant factor. In M16, the largest BT difference is at 0.02K, which is smaller for BT than BT - M16. However, in the band BT - M16, the difference is larger for BT than BT - M16.

Figure 3. The cumulative histogram for Bay of Bengal over tropical region on June 9, 2013 in M15-M16 (Left), as well as M15 and M16 (Right).

Figure 4. The comparison of effective BT difference between LBLRTM and the VIIRS observation for tropical and polar cases.

Summary

• LBLRTM results show that the striping pattern in VIIRS SST imagery is most likely related to the difference between band averaged SST and detector level SST. The effective RSR has some atmospheric dependency. The results are consistent with MODTRAN results.

• Ten case studies using VIIRS SDR BT observation over tropical and polar regions also show that the detector level difference in tropical region is more obvious than that in polar region. The BT bias is larger for warm and moist atmosphere, but smaller for cold and dry atmosphere. Band M16 is more sensitive to the atmospheric conditions.

• In general, VIIRS SDR BT observation has larger variability when comparing with the model output. It is not easy to effectively validate. The difference due to atmospheric conditions or water vapor is small and not a dominant factor for striping.

• Further study will focus on detector stability and fixed pattern noise.

Acknowledgement: Thanks Yan Bai for providing sample data.

References


Assessment of scan-angle dependent radiometric bias of Suomi-NPP VIIRS day/night band from night light point source observations

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Abstract
The low gain stage of VIIRS Day/Night Band (DNB) on Suomi-NPP is calibrated using onboard solar diffuser. The calibration is then transferred to the high gain stage of DNB based on the ratio determined from data collected along solar terminator region. The calibration transfer causes increase of uncertainties and affects the accuracy of the low light radiances observed by DNB at night. Since there are 32 aggregation zones from nadir to the edge of the scan and each zone has its own calibration, the calibration versus scan angle of DNB needs to be independently assessed. This study presents preliminary analysis of the scan-angle dependence of the light intensity from bridge lights, oil platforms, power plants, and flares observed by VIIRS DNB since 2014. Effects of atmospheric path length are also considered. Other effects such as light changes at the time of observation are also discussed. The methodology developed will be especially useful for JPSS VIIRS DNB due to the nonlinearities effects at high scan angles, and the modification of geolocation software code for different aggregation modes. It is known that J1 VIIRS DNB has large nonlinearities across aggregation zones, and requires new aggregation modes, as well as more comprehensive validation.

Introduction
The Visible Infrared Imaging Radiometer Suite (VIIRS) is one of the key instruments on the Suomi National Polar-Orbiting Partnership (Suomi NPP) satellite designed primarily to observe clouds and earth surface parameters. Among the twenty-two bands of VIIRS onboard the NPP satellite, the Day/Night Band (DNB) represents an unprecedented night observation capability. It is superior to its predecessor, the Operational Line Scanner (OLS) on the Defense Meteorological Satellite Program (DMSP), in both spatial and radiometric performance because it has a finer spatial resolution of constant 742 m across the three thousand kilometer scan. The Day/Night band (DNB) is also the first to utilize onboard calibration [1].

The VIIRS DNB uses advanced onboard aggregation techniques to achieve constant spatial resolution across scan with 32 aggregation zones. Since each zone has its own calibration, it is not easy to validate the calibrated radiances across the zones. It is also found that in J1 VIIRS prelaunch testing, a large nonlinearity exists in the higher calibration, it is not easy to validate the calibrated radiances across the zones. The methodology developed will be especially useful for JPSS J1 VIIRS due to the nonlinearities effects at high scan angles, and the modification of geolocation software code for different aggregation modes. It is known that J1 VIIRS DNB has large nonlinearities across aggregation zones, and requires new aggregation modes, as well as more comprehensive validation.

Methodology
To evaluate the DNB radiometric response versus scan angle, we select ground based night light sources. Ideal sources should be stable over time and spatially isotropic (or radiating equally in all directions). However, not many targets are truly stable due to fluctuations of power supplies, and atmospheric changes. Analysis of night lights from DNB led us to focus on point sources such as bridges, oil platforms, and power plants. We are mostly interested in the lights over water because this greatly reduces lunar reflection from the surrounding areas, which would complicate the analysis.

Figure 1 shows an example of nighttime lights from the oil platform Holly located near Los Angeles. It is about 50 meters long and 29 meters wide over the water. The lights appear to be always on at night and are relatively stable as a point source for DNB radiance and geolocation analysis. Although oil platforms have lights on overnight, their stability long term is not well known. For example, some lights on the platform may be turned on and off at a given schedule. This increases the uncertainties for radiance validation.

Figure 2 shows the power plant located on the west about 40 miles away from Phoenix AZ, which is a good candidate for a ground based night light source. Although there is little light around the power plant, and also Arizona has more clear sky at night, the ground lunar reflection may affect the stability of DNB radiance and geolocation.

Finally, gas flares are assumed to be on all the time, but the stability is unclear. Furthermore, it is not clear how flare intensity is related to oil production volume, and whether there is a daily schedule. In this study, we also tested using gas flares in the mid-east region. Despite the challenges, we believe that by using multiple sites and multiple types of light sources, the uncertainties in those factors can be reduced.

The potential use of this method for J1 DNB aggregation (Figure 4) evaluation is assessed.

Data Sets and Analysis Results
The data set used for the analysis is VIIRS DNB SDR data with geolocation/terrain correction for Suomi NPP.

Table 1. Data sets used in the study

<table>
<thead>
<tr>
<th>DNB observation</th>
<th>Data set used from year to year (2014-2015)</th>
<th>DNB observation</th>
<th>Data set used from year to year (2014-2015)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNB observation</td>
<td>DNB observation</td>
<td>DNB observation</td>
<td>DNB observation</td>
</tr>
</tbody>
</table>

Conclusion
Preliminary analysis of the scan-angle dependence of the light intensity from bridge lights, oil platform, power plants, and flares observed by VIIRS DNB since 2014 are presented in this study. Results show that there appears to be a scan angle dependent radiometric bias, with a low radiance at nadir while gradually increases towards edge of the scan. The pattern is found in both the San Mateo bridge and the oil platform holy sample. Although it is less clear for the Arizona power plant and Bahrain cases. It is possible that this effect is due to the DNB aggregation zones on Suomi NPP VIIRS, which would also help study the effect of J1 VIIRS DNB nonlinearity at high scan angles, which requires the use of new aggregation modes. However, the results are preliminary and more analysis is needed to get a better understanding of this effect. Other effects such as atmospheric path length and light on/off schedule as well as traffic volume may also contribute to this pattern. We found that the point sources over water have the clear advantage than the ground base point sources for the radiance and geolocation validation analysis since there is little reflection from the water and this reduces the uncertainties compare with the ground point source.

Other causes include atmospheric path length and scattering, response versus scan (RVS) angle, the point analysis versus scan from data collected along solar terminator region, time of the observation due to traffic lights, calibration bias across aggregation zones. Finally, air glow [4] may have an impact but the magnitude is on the order of 1.0e-9 which cannot explain the pattern in Figure 5.

Figure 6 shows the response vs. scan for the oil platform holy located on the west coast near Los Angeles. A similar scan angle dependent bias is also found here. At nadir, the radiance of 6e-9 w/cm2-r is much lower than that at the edge of the scan ( Compared to the lights on the San Mateo bridge, it seems that the radiance from the oil platform Holy is not as stable).

The power plant in Arizona and the passport control of Bahrain are the ground base point sources. In comparison with Figure 5 and Figure 6, the pattern for Figure 7 and Figure 8 are not very clear. However, there is a preliminary point source observation which may have disrupted the pattern. Also it can be due to ground reflection of street light.

References

Acknowledgment:
This study is partially funded by the Joint Polar Satellite System (JPSS) program.
We present an overview of the field campaign support capabilities in various areas at the University of Maryland:

- Overflight field campaign support
- Lunar observation at UMD Astronomical Observatory
- Ground measurements of aerosol optical thickness (AOT) and PM 2.5
- Integration of modular spectrometer and Unmanned Aviation Vehicle (UAV) rotary drone system to support field measurements
- Hardware integration to enable automatic data acquisition.

The University of Maryland Astronomical Observatory serves as an important component of the teaching and research program in the Department of Astronomy. It also brings the excitement of astronomy to the University community and the general public through public programs.

The Observatory has four permanently mounted telescopes on site, and a collection of 12 portable telescopes used both on and off site.

- 8" NASA Refractor; 7" Astro-Physics Refractor
- Celestron 14" Schmidt-Cassegrain Reflector; 20" Eichner Bent Cassegrain Reflector

An example of participating field measurements in support of the NASA HYSPIRI mission to collect ground spectral reflectance and aerosol data near Los Angeles with ASD spectrometer and sun photometer provided by NOAA/NESDIS/STAR:

- These ground spectral reflectance and aerosol data are analyzed to calibrate over-flight remote sensing measurements.

We thank Frank Padula and Aaron Pearlman for close collaboration with GOES-R Calibration Working Group. Thanks are extended to JPSS program scientists for field campaign opportunities. We look forward to supporting VIIRS field campaign.
Abstract

• As a part of post-launch Cal/Val, NOAR STAR developed and has maintained the Integrated Calibration and Validation System (ICVS) for Long-Term Monitoring (LTM) of the sensor performance. The Visible Infrared Imager Radiometer Suite (VIIRS) is the one of the key instruments onboard the Suomi National Polar orbiting Partnership (S-NPP) satellite, which was successfully operational since its launch on October 28, 2011.

• This poster is focused on significant VIIRS significant anomalous events in year 2014 that were identified and analyzed through the ICVS LTM webpage. Firstly, the Single Board Computer (SBC) lock-up events randomly occurred four times in last year. It was caused by the cosmic high energy particle hits and the improved design was applied to the next J1 VIIRS. During the SBC lock-up events, there were unrecoverable data losses. The second event affected reflectance (or radiance) in the Reflective Solar Band (RSB) calibration. The sudden SD degradation LUT (H-factor) changes were occurred on June 28th and July 11th of 2014, which had ripple effect on F-factors. The H-factor changes affected VIIRS radiometry up to 1.5 percent especially in band M1. Thirdly, the calibration coefficients (CC) were updated on May 9th to be zero mostly affecting I3 approximately 1 percent drop in F-factor. Lastly, other operational anomalies such as ‘Night Time Day Mode’ and ‘Sync Loss’ events are explained in detail.

• The VIIRS ICVS LTM webpage has provided in-depth instrument monitoring information with very simple web-interface from imagery analysis to radiometric calibration. The calendar based browsing capability also provided excellent accessibility to locate the timing of the anomalous events. The VIIRS ICVS LTM webpage will be improved to meet the growing needs for the high quality satellite data providing essential information on the satellite performance.

Introduction

• STAR Integrated Cal/Val System (ICVS) Long-Term Monitoring (LTM) system
  ▫ Turn instrument measurements into accurate environmental parameters.
  ▫ Ensure high-quality satellite imagery for forecasts
    • e.g., hurricane tracking and monitoring.
  ▫ Deliver accurate products for weather forecasts and environmental monitoring.
  ▫ Ensure the integrity of the climate data records from broader satellite instruments.

• VIIRS ICVS LTM webpage provides (as shown in Figure 1)
  ▫ Imagery Analysis (Global true color image, VIIRS single band image, VIIRS overall SDR quality )
  ▫ Measurement trending plots (RSB/TEB F factors, H factor)
  ▫ Solar Diffuser Stability Monitor (SDSM) related trending results
  ▫ Solar Diffuser (SD) related plots per band, Blackbody (BB) related plots per band, Space View (SV) related plots per band.
  ▫ Instrument health, Volt and current trending plots, Instrument/Focal Plane/Circuit Card Assembly/Scan Cavity temperatures.

S-NPP VIIRS Significant Events in 2014 Monitored by NOAA ICVS Web-page

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1Earth Resource Technology (ERT), 2STAR/NESDIS/NOAA

Significant Events in Year 2014

• Single Board Computer (SBC) Lock-Up Events
  ▫ Data loss occurred during the SBC Lock-Ups in Figure 1 on October 9th.
  ▫ Caused by high energy particle hits and improvements are implemented to the next J1 [1].
  ▫ The staring locations and orbits were varying for all the events as shown in Table 1.
  ▫ SV counts were reset to high values because of the new DC restore values in Figure 2.
  ▫ SD counts were also moving along with the SV, the bias corrected SD responses remained in stable levels in Figure 2.
  ▫ The SBC lock-up didn’t affect the Reflective Solar Band (RSB) calibration.
  ▫ No huge impact on TEB calibration, since the blackbody (BB) temperature was immediately went back to the normal temperature of 292.69K as shown in Figure 3.

• Reflective Solar Band (RSB) F and H factor Trend Changes
  ▫ Due to flattening anomaly in SD degradation in 2014, there were two times of sudden updates in SD degradation, i.e. the H-factors on May 23rd and July 11th, 2014.
  ▫ The flattening anomaly started approximately from Feb 4th to May 19th as shown in red dotted lines in Figure 4.
  ▫ To compensate the flattening effects, two sudden H-factor updates were applied in operational H factor in blue dotted lines.
  ▫ Figure 5 show significant F-factor discontinues directly affected radiometric calibration especially in M1–M4 bands.

• Delta C0=0 Coefficient Update
  ▫ The C0 coefficients represent thermal responses of the detectors and electronics.
  ▫ The C0 values were set to zero for all RSB bands and the C2 values were derived by the prelaunch test results starting from May 9th.
  ▫ Changes were < 0.5% in most of the RSB bands, but I3 had approximately 1% change in Figure 6.

• Night Time Day Mode Anomaly
  ▫ Day mode collections (Op_day) were reversed to night mode operation (Op_night) approximately between 15:00 and 21:00 on June 12th.
  ▫ Operational team quickly recovered the anomaly. RSB SDR data are missing except bands M7, M8 and M10.

• VIIRS RTA and HAM Synchronization Loss (Sync Loss)
  ▫ The root cause of this event is accumulation of charges in the Scan Solar Diffuser Stability Monitor (SDSM) related trending results
  ▫ There were sync loss events during 2014 as listed in Table 2.
  ▫ Figure 12 shows global image of quality flag in band M2 on 4/2/2014.

Table 1. Detailed information on S-NPP VIIRS SBC lock-up events in 2014.

<table>
<thead>
<tr>
<th>SBC lock-up event #</th>
<th>Date</th>
<th>Time</th>
<th>Duration</th>
<th>Starting Location</th>
<th>orbit</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>2/4/2014</td>
<td>17:38-21:35</td>
<td>3 hours 30 minutes</td>
<td>South America Day</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>9/26/2014</td>
<td>18:25–18:33</td>
<td>10 minutes</td>
<td>Arctic near Asia Day</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>10/9/2014</td>
<td>17:22–19:31</td>
<td>2 hours 9 minutes</td>
<td>South America Day</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Detailed information on the Sync Loss in 2014.

<table>
<thead>
<tr>
<th>Sync Loss #</th>
<th>Date</th>
<th>Starting Time</th>
<th>Ending Time</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>3/8/2014</td>
<td>16:29:26</td>
<td>16:31:06</td>
<td>1 min 42 sec</td>
</tr>
<tr>
<td>37</td>
<td>3/12/2014</td>
<td>03:15:53</td>
<td>03:17:32</td>
<td>1 min 39 sec</td>
</tr>
<tr>
<td>38</td>
<td>4/2/2014</td>
<td>20:14:21</td>
<td>20:15:52</td>
<td>1 min 31 sec</td>
</tr>
<tr>
<td>39</td>
<td>5/20/2014</td>
<td>07:52:29</td>
<td>07:55:19</td>
<td>1 min 56 sec</td>
</tr>
<tr>
<td>40</td>
<td>11/8/2014</td>
<td>15:09:51</td>
<td>15:11:30</td>
<td>1 min 39 sec</td>
</tr>
</tbody>
</table>

Summary

• The NOAA ICVS LTM webpage for VIIRS sensor is continually providing critical global images, quality flags and calibration related trending plots.
• Indicating sensor status and data coverage.
• The S-NPP VIIRS related significant events in year 2014 are summarized here such as, Single Board Computer (SBC) Lock-Up Events, RSB and H Factor trend changes, delta C0=0 coefficient update, night time day mode anomaly, RTA and HAM synchronization loss events.
• The VIIRS ICVS LTM team is ready to apply current system to next J1 trending.

References

Suomi NPP VIIRS SWIR Band (2.25 µm) has larger radiometric uncertainty compared to the rest of the reflective solar bands. This is due to a number of reasons including prelaunch calibration uncertainties. One of the most commonly used techniques to verify the radiometric stability and accuracy of VIIRS is by intercomparing it with other well calibrated radiances such as MODIS. However one of the limitations of using MODIS is that VIIRS band M11 RSR doesn’t overlap with MODIS bands at all. Thus the accuracy of intercomparison relies completely on how well the spectral differences are analyzed over the given target. This study uses desert sites to analyze M11 radiometric performance. In order to better match the RSR between instruments, we have chosen Landsat 8 OLI SWIR band 2 (2.20 µm) to perform intercomparison. This is mainly because OLI SWIR 2 fully covers the VIIRS band M11 even though OLI has much wider RSR compared to VIIRS. The impact due to spectral differences is estimated and accounted for using EO-1 Hyperion observations and MODTRAN.

Results

• VIIRS and OLI measurements agree very well to less than 1.5%, the spectral differences are negligible.

• MODTRAN reflectance is scaled to match the maximum value with Hyperion near 2.2 µm. Reflectance spectra from Hyperion and MODTRAN match well with each other except over the region where atmospheric absorption is large.

• MODTRAN reflectance is scaled to match the maximum value with Hyperion near 2.2 µm. Reflectance spectra from Hyperion and MODTRAN match well with each other except over the region where atmospheric absorption is large.

• The residual bias of VIIRS is the difference between observed bias and spectral bias.

• Even though VIIRS and OLI measurements agree very well to less than 1.5%, the spectral differences suggested TRUE large bias.

• The residual bias of VIIRS is nearly 6% relative to OLI and nearly 0.5% relative to MODIS.

Summary

• The radiometric stability of VIIRS moderate resolution reflective solar band M11 analyzed using Libya-4 desert is better than 1% with uncertainty less than 1%.

• VIIRS M11 radiometric bias (analyzed after accounting for spectral differences) estimated through VIIRS band M11 inter-comparison using TDA reflectance time series over desert suggest nearly 5.4% relative to OLI and less than 0.5% relative to MODIS.

• The result from this study is valid for low radiance under the assumption that detector responses are linear and results obtained at higher radiance is also valid at lower radiance.

• It is assumed that all Aqua MODIS and Landsat-8 OLI are correct in absolute scale and the sensor intercomparison is performed with MODIS band 2 (2.2 µm) to assess how well the band M11 is calibrated.

• M11 doesn’t overlap with any Aqua MODIS bands. Still the comparison is performed with closest matching MODIS band assuming that the spectral differences could be characterized using hyperspectral measurements.

Methodology

Sensor

S-NPP VIIRS

Landsat-8 OLI

Aqua MODIS

EO-1 Hyperion

Spatial Resolution

750 m

30 m

1 km

30 m

Sensor Intercomparison

Comparing VIIRS and OLI Reflectance with MODIS RSR

 NOAA/NESDIS/STAR, College Park, MD

CIRA, Colorado State University, College Park, MD

References:


Acknowledgment:

This study is partially funded by the Joint Polar Satellite System (JPSS) program.
Monitoring the VIIRS Reflective Solar Band Calibration Stability Using Deep Convective Clouds

Wenhui Wang* and Changyong Cao

*Earth Resource Technology, Inc., Laurel, MD, USA; †NOAA/NESDIS/STAR, College Park, MD USA

1. Introduction

The Visible and Infrared Imaging Radiometer Suite (VIIRS) onboard the Joint Polar Satellite System (JPSS) / Suomi National Polar-Orbiting Partnership (NPP) satellite has 22 spectral bands, with 14 Reflective Solar Bands (RSB), 7 Thermal Emissive Bands (TEB) and 1 Day Night Band (DNB). Onboard calibration of VIIRS is complex, especially for the RSBs and DNB, which are calibrated using a full-aperture solar diffuser (SD) and the degradation of SD is monitored by a solar diffuser stability monitor (SDSM). Significant SD degradations were observed in the visible and near-infrared spectrum. It is important to use independent validation time series to evaluate post-launch calibration stability of VIIRS RSBs and DNB.

2. VIIRS Dataset Used

• Area of Interest: Latitude: -25° to 25°; Longitude: -150° to 60°
  An area also observed by GOES-East & GEOS-West
• Bands Used:
  - RSB bands: M1-M5, M7-M11, I1-I3, DNB
  - TEB bands: M15 (10.729 µm) & I5 (11.469 µm)
• Time Period: March 2012 – June 2015

3. VIIRS DCC Identification Method

VIIRS DCC identification criteria (Wang and Cao 2014, 2015):
1. TB11 (M15 or I5) <= 205 K;
2. Standard deviation of TB11 of the subject pixel and its eight adjacent pixels <= 3%;
3. Standard deviation of VIS/NIR reflectance of the subject pixel and its eight adjacent pixels <= 3%;
4. Solar zenith angle (SZA) <= 40 degrees;
5. View zenith angle (VZA) <= 35° (to avoid the bow-tie effect in VIIRS dataset);
6. DNB radiances were mapped to M15 lat/lons before DCC pixels were identified using M15 TB11.

4. Monthly Probability Distribution Functions for VIIRS DCC

• Anisotropic effect is corrected using Hu et al. (2004) Angular Distribution Model (ADM)
  • Mean & mode of the monthly PDFs are two important indices when using DCC for calibration validation
  • Mean ratio is used to validate individual bands calibration stability monitoring
  • More stable when means in the VIS/NIR spectrum
  • Mean ratio is used for inter-channel relative calibration stability monitoring
  • Mean ratio more stable than mode ratio

5. DCC Time Series for Individual Bands Calibration Stability Monitoring

M1-M5, M7 (VIS/NIR 0.411 – 0.862 µm)
• SD: <=0.9%
• Max - Min <=4.5%
• M5 & M7 are relatively more stable
• M6 saturated over DCCs, not considered

M8-M11 (SWIR 1.238 – 2.257 µm)
• SD: <= 1.1 – 3.1%
• Max - Min: 3.6 – 10.2%
• M8 is relatively more stable

I1, I2 & I3 perform similar as M5, M7, M10, respectively

6. Inter-Channel Relative Calibration Stability Monitoring Using DCC Mean Band Ratio Time Series

M1/M4, M2/M4, M3/M4, I5/I7 band ratio time series

M3/I4 & M2/M4: 2012 & 2013 show different ratio patterns
• Correspondent with DOC group complaints
  - M observed trend is observed in the M3/M7 band ratio time series.

7. DCC Time Series vs. IDPS F-factor Time Series

1. Apr 2012 IDPS code & LUTs changes
2. Oct 2013 SDSM misalignment
4. Nov 2012 SD processing param. change

DCC time series correlated with F-factor time series Correlations are stronger since January 2014

8. Summary

• STAR VIIRS SDR support team developed DCC time series for VIIRS calibration stability monitoring
  • https://cs.star.nesdis.noaa.gov/NCC/VSTS, update monthly
  • Completed M1-M5, M7-M11 & DNB (2012/03 – present)
  • Capable of capture calibration changes

• RSB calibration stability
  • M-Bands VIR/NIR Bands (M1-M5, M7)
    - M1-M4 have large calibration changes
    - M5&M7 are relatively stable
  • M1-M4 & M2/M4: 2012 & 2013 show different ratio patterns
    - M5&M7 are relatively stable
  • M9-M10 large calibration changes

• I-Bands (I1-I3) perform similar as M5, M7, M10, respectively
• DNB is relatively stable after April 2013

References

**Intercomparison of SNPP/VIIRS Longwave Infrared Channels Using Hyperspectral Radiance from GOSAT FTS and MetOp-A IASI**

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**Introduction:**
- The Visible Infrared Imaging Radiometer Suite (VIIRS) onboard Suomi-NPP has four longwave infrared bands (I5, M14, M15 and M16).
- Calibration of VIIRS thermal band radiance has been performed onboard. Inter-comparison between VIIRS and Cross-track Infrared Sounder (CrIS) becomes difficult for M14-16 because CrIS has a spectral gap (8.26um to 9.14um) that does not cover M14, and the Spectral Response Function (SRF) of M15 and M16 are not fully covered.
- The Greenhouse Gases Observing SATellite (GOSAT) is equipped with a Fourier Transform Spectrometer (FTS). The band 4 of FTS measures hyper-spectral radiance (5um-15um). It is feasible to compare the FTS measurements with the VIIRS longwave infrared channels.
- Infrared Atmospheric Sounding Interferometer (IASI) onboard Metop-A covers a complete hyper-spectra (3.63um-15.5um). It can also be used to compare with VIIRS M14-16 bands.
- In this study, inter-comparison between FTS and VIIRS, between IASI and VIIRS for the three longwave infrared bands are carried out.

**Methods:**
- Simultaneous Nadir Overpass (SNO) locations and time between FTS and VIIRS, and between IASI and VIIRS are determined using orbital model (SGP4) and two-line-elements data. Collocated pixels are obtained by comparing actual geolocations near the given SNO location and time.
- We use the FTS/VIIRS datasets of 01/2014-06/2014, and IASI/VIIRS datasets of 01/2014-01/2015.
- Convoluting VIIRS M band SRF and hyperspectral radiance from FTS and IASI at the collocated FOVs to obtain the simulated VIIRS radiance.

**Results:**
- **FTS/VIIRS:** The simulated VIIRS radiance is close to observed for all three bands, with the brightness temperature difference of 0.54±0.36K for M14, 0.50±0.35K for M15, 0.46±0.34K for M16 (FTS minus VIIRS). The radiance ratio (FTS/VIIRS) is 1.011±0.007 for M14, 1.008±0.006 for M15, 1.007±0.005 for M16. The radiance ratio has a weak positive dependency on the brightness temperature for all three bands.

- **IASI/VIIRS:** The brightness temperature difference (IASI-VIIRS) is 0.10±0.15K for M14, -0.02±0.15K for M15, -0.07±0.16K for M16. The radiance ratio is 1.003±0.004 for M14, 1.000±0.003 for M15 and 0.998±0.004 for M16. Weak negative ratio dependency on scene temperature can be seen for M14, no clear ratio dependency for M15 and M16.

**Summary:**
- Both IASI and GOSAT FTS can be used to compare with the VIIRS M14-16, especially for M14 for which CrIS does not have coverage.
- For comparison between FTS and VIIRS, the brightness temperature of FTS has a higher bias of 0.54K for M14, 0.50K for M15 and 0.46K for M16.
- For comparison between IASI and VIIRS, the brightness temperature of IASI has a bias of 0.10K for M14, 0.02K for M15 and -0.07K for M16.
- The higher bias between FTS and VIIRS may be due to the inclusion of FOVs within 5° scan angle of VIIRS since FTS has very low number of FOVs in each swath.

**Acknowledgement:**
The GoSAT/FTS dataset is from http://data.gosat.nies.go.jp/GosatUserInterfaceGateway/gui/GuiPage/open.do. The VIIRS/IASI data are from http://peate.ssec.wisc.edu/flo/search. This project is funded by NOAA/NESDIS/STAR.
**Summary**

The Dark OMPS Generator Script (DOGS) is a Perl wrapper developed by the NOAA/NESDIS/STAR Algorithm Integration Team (AIT) to facilitate the Ozone Mapping and Profiler Suite (OMPS) Dark Table production process. Weekly Dark Table updates are important for correct radiance values and accuracy of other downstream ozone operational products which use either the OMPS Nadir Profiler (NP) or OMPS Nadir Mapper (NM) data.

**What is DOGS?**

DOGS is a wrapper script to run NASA program generated executables (PGEs). The wrapper script performs these major functions:

- Input and ancillary data are gathered and linked into processing directories.
- Program control files (PCF) are generated based on date.
- Environmental variables are sourced and setup.
- Output data are copied to directories specified by the user.

**Purpose**

Currently, Dark OMPS Tables are generated manually on the NASA PEATE system on a weekly basis. DOGS will automate the table production and allow the process to transition to NOAA’s Government Resources for Algorithm Verification, Independent Test and Evaluation (GRAVITE) operational system.

**STAR AIT**

STAR AIT provides expertise on integration of JPSS algorithms into operational systems and performs the following tasks:

- Code Testing and Integration in Algorithm Development Library (ADL)
- Communication with Science Teams and DPES
- Troubleshooting, Change Request Submission, Consultancy to Science Teams and DPES
- Facilitation of Lifecycle Reviews

**Input Output Data Flow**

Below is the process flow diagram showing the creation and organization directories needed to run DOGS and how input and output data are linked in the directory structures. This diagram is a visual aid to understand how the different directories listed in their user configuration files are used.

**Wrapper Shell Script**

**Perl Script**

**Input Output Data Flow**

This is a flow diagram of the main executable that creates the OMPS dark tables. Users only need to type this one executable command to generate the OMPS dark tables. This executable shell script sets up environmental variables and executes the Perl script shown on the right column of this poster.

This diagram shows how the program uses the file user_list.list which contains multiple configuration files.

This flow chart uses the example that each configuration file is dependent on date. The configuration file actually has many parameters, some of which are: date, output directories, and PGEs.
STAR Algorithm Integration Team: Configuration Management

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Overview

Configuration Management supports routine algorithms integration work for the STAR Algorithm Integration Team (AIT) by identifying, controlling, maintaining and verifying all relevant versions of Configuration Items (CIs).

STAR AIT brings technical expertise and support to product algorithms, specifically in testing and validating science algorithms in the Algorithm Development Library (ADL) environment. STAR AIT assists JPSS science teams in implementing algorithm changes.

STAR AIT utilizes CM using IBM Rational ClearCase and ClearQuest and adopts ClearCase Unified Change Management (UCM) approach for JPSS related projects. Naming conventions are employed for the configuration identification process of ClearCase Streams, Views and Baselines. Streams are used to enable parallel development in projects. With appropriate branching strategy, developers from both AIT and science teams are able to create private development streams to access projects associated software, data and documentation. For science teams without access to ClearCase, AIT assists to integrate all corresponding algorithms updates into ClearCase and verify the changes. AIT is also responsible for design, development and implementation of the tools associated with tracking CIs and defining the change process.

Branching Strategy for JPSS ADL project

Configuration Item and Identification

Configuration Items (CIs) are aggregations of data documentation, software and hardware that are designated for configuration management. CIs provide visibility during the lifecycle phases and are supported by the CM system. Items subject to configuration control within JPSS related projects include:

- ADL software
- JPSS Algorithm packages
- Science Teams Delivered Algorithms and Updates
- Acquired software (e.g. COTS)
- LUTs
- AIT Scripts (chain run scripts, CM related scripts, etc.)
- Tools (e.g. compilers, libraries)
- AIT Documents
- JPSS ATBDs

STAR AIT CM has the responsibility for identifying and selecting which elements and components can become CIs. Configuration Identification consist of setting and maintaining baselines that define the CIs at any point in time. Depending on the development lifecycle phase, different baselines are progressively established.

Ongoing Projects

JPSS ADL is created for the code testing and algorithm updates integration/validation within ADL3.x and ADL4.x environments.

JPSS ADL BLK2 is created for the code testing and algorithm updates integration/validation within ADL5.x environments.

NUCAPS is created for the code testing and algorithm updates integration/validation within NOAA Unique CRS ATMS Processing System (NUCAPS).

JPSS ATBD is created for the CM of transferred JPSS ATBDs and the ATBD updates afterwards.

Configuration Management for JPSS ATBD

With the transition of JPSS ATBD to STAR, AIT CM is responsible to perform the configuration and change control through the ATBD documents development lifecycle after the transfer. All the transferred JPSS ATBDs (both WORD and PDF formats) are selected as CIs and labeled with appropriate baselines to establish revision history and maintain a definitive basis for control and status accounting.

STAR JPSS ATBD Naming Convention:

<Document ID>_<Mission ID>_<Satellite ID>_<Index>_JPSS_ATBD_<Product Name>_<Revision>

Revision: Change request will be submitted to IBM Rational ClearQuest for changes to the CM plan for JPSS ATBD.

Configuration Management for JPSS ATBD

STAR AIT CM defines three different types of branches for project JPSS ADL:

The MASTER branch (ADL_MAJOR_INT stream in ClearCase UCM project) is used to reserve the operational code (MX Builds).

The INTEGRATION branch (ADL##_MX##_DEV_INT stream) is the integration branch used by developer from AIT or science teams to deliver their changes to or get other developers updates from.

The DEVELOPMENT branch is created by developers to implement updates, on which AIT developers can test and validate the algorithm updates.

Future Project and Planning

STAR AIT is making CM plan for JPSS Cal/Val Maturity Documents.
Algorithm Change Process

<table>
<thead>
<tr>
<th>Algorithm Change Recommendations (ADR filing)</th>
<th>Joint Discussion &amp; Recommendations (DRAT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algorithm Change Request Package Preparation &amp; Submission</td>
<td>Algorithm Testing and Verification</td>
</tr>
<tr>
<td>Algorithm Engineering Review Board (AERB)</td>
<td>Integration and Testing</td>
</tr>
<tr>
<td>Science &amp; Operational Verification</td>
<td>Deploy to Operations</td>
</tr>
</tbody>
</table>

**ADR Filing:** Usually Algorithm Discrepancy Reports are filed by the scientists. At times the algorithm JAM or AIT POC files the ADR.

**DRAT:** The DRAT discussions are held to discuss the ADR and solution ideas. AIT POC participates in DRAT discussions.

**TIM (Technical Interchange Meetings):** Depending on the decision of the science team members, a TIM might be organized by the algorithm JAM. STAR AIT participates in TIM.

**Algorithm Change Request Package Preparation and Submission:** AIT’s major contribution is focused on this task. This includes testing, integration, documentation preparation, adding updates, preparing change request package and submitting to DPES.

**DPES Testing:** After AIT delivers the change request package, testing and verification is being done by DPES and AIT is involved in this task by guiding the DPES in case of any discrepancy in the results, and supporting DPES with data and information when required.

**AERB Review:** This review is held to discuss and verify that the proposed solution for the respective discrepancy is being tested and verified and the results support that AIT participates in the review.

**Others:** After AERB completes the review, AIT is general in out of the loop. However, AIT participates on occasions in “Science and Operational Verification” phase before the final deployment to operations.

**Algorithm Change Process Flow**

1. **Get ADR Version from Raytheon:**
2. **Integrate at Class A (ITC):**
3. **Create Development & Stress & Test:**
4. **Install Data (SIT, Ancillary, Auxiliary):**
5. **Change Geneale

**Contents of the Delivered Algorithm Package (DAP):**

- OMPS NP V8 Pro Algorithm
- OMPC TC V8 Algorithm
- Aerosol EDR
- Land surface abebo LUT updating
- Adjust Quality Flag for Thin Cirrus in LAND Surface Temperature (LST) and Update LUT
- Add Quality Check for Active Fire
- Updated PCT for CrIS SDR
- Updated PCT for AITM SDR
- Equation Modification for Sea Surface Temperature and Evaluating Downstream Impact
- Roll Back LST LUT from Provisional to Beta Version
- OMPS Cal SDR Dark Table Creation
- VIIRS Software Reflectance Algorithm Updates
- New Rain Algorithm for CrMiSS (Cross Track Infrared and Microwave Sounder Suite)
- Wavelength Shift and New Ozone mixing Fraction for OMPS
- Implementing NOAA Global Multi-sensor Automated Snow/Ice Map (GMASI) Tile

**Example Contributions to S-NPP Algorithms:**

- OMPS NP V8 Pro Algorithm
- OMPC TC V8 Algorithm
- Aerosol EDR
- Land surface abebo LUT updating
- Adjust Quality Flag for Thin Cirrus in LAND Surface Temperature (LST) and Update LUT
- Add Quality Check for Active Fire
- Updated PCT for CrIS SDR
- Updated PCT for AITM SDR
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- Implementing NOAA Global Multi-sensor Automated Snow/Ice Map (GMASI) Tile

**Example Contributions to J1 Algorithms:**

- OMPS NM SDR Phase 1 and 2 J1 Uppers Deliveries with algorithm updates for de-aggregation and decompression criteria
- OMPS NP SDR J1-Uppers Package
- VIIRS SDR Package
- VIIRS GEO Package
- CrIS SDR Package for Full Resolution and Normal Resolution Processing Capabilities
- CrIS SDR Package to correct fringe Count Error
- VIIRS Active Fire DAP to NDE

**Abbreviations:**

- AITB: Advanced Technology Microwave Sounder
- CrIS: Cross-track Infrared Sounder
- DRAT: Discrepancy Report Action Team
- EDR: Environmental Data Record
- JAM: JPSS Algorithm Manager
- OMPS: Ozone Mapping and Profiler Suite
- SDR: Sensor Data Record
- SRS: Software Requirement Specification
- VIIRS: Visible/Infrared Imager Radiometer Suite
J1- Readiness

The JPSS Algorithm Integration Team (AIT) brings technical expertise and support to product algorithms, specifically in testing and validating science algorithms in the Algorithm Development Library (ADL) environment.

What we do:
- Assist teams with code updates, testing, and deliveries
- Provide technical support and expertise to teams
- Provide avenue for effective configuration management
- Facilitate a structured test and review process for new algorithms

We have developed a variety of in-house software for organizing, managing, and transitioning product algorithms. Additionally, we are taking leadership in the process of enhancing algorithms to meet upgraded requirements for J1. Our involvement in the development and review process, in addition to our expertise in integrating the evolving algorithms into ADL, will make it possible to plug the new algorithms into the operational system with greater efficiency and ease.

J1 Algorithm Review Milestones

STAR AIT coordinates with science teams to present algorithm reviews in keeping with the SPBSR process. Algorithm Reviews have been completed for all major algorithm changes for J1. Complete review dates are listed in the table below. These algorithm changes include:
- Addition of Top-of-Canopy NDVI output to the Vegetation Index algorithm
- Addition of high-resolution processing capabilities for CCE SDR algorithm
- Addition of high-resolution processing capabilities for the OMPS NP and NTC algorithm
- Addition of the Fire Radiative Process and Fire Map to the Active Fire algorithm. Transition algorithm to the NDE operational system.

Algorithm Change Process

The Algorithm Change process is regulated to preserve the integrity and functionality of the operational system.

As we look toward J1 Readiness, many algorithm changes are not in response to discrepancies and errors in the code, rather changes and updating the code to accommodate:
- New J1 Requirements
- The upgrade to the Block 2 operational system.

Algorithm updates follow the established change process documented in the Algorithm Change Management Plan. New algorithms (related to new J1 products) follow an additional review process prior to the submission of the change package to DPER.

Integration Specialists

AIT has five integration specialists each assigned to specific Sensor Data Record (SDR) and Environmental Data Record (EDR) teams based on expertise. Integration specialists:
- Interact directly with algorithm teams during development, testing, and integration
- Attend meetings with science teams to keep apprised of algorithm status
- Provide test results to algorithm team
- Provide chair run test results to all affected teams
- Prepare and deliver algorithm packages
- Maintain support through review and integration process

Quality Assurance

STAR AIT in conjunction with JPSS STAR Management (J-STAR) has developed a Quality Assurance Plan that describes the QA procedures for the STAR JPSS project. The AIT QA Lead is responsible for maintaining situational awareness of the JPSS project as a whole and coordinating with management and oversight teams.

For QA purposes, AIT:
- assists with Chain/Chainquest for algorithm configuration management
- complies with the Algorithm Change Management procedures put forth by Data Products Engineering & Services (DPES)
- assists algorithm teams in maintaining accurate and up-to-date documentation throughout the development process

Algorithm Review Process

New algorithms developed for J1 are subject to the STAR Enterprise Lifecycle Review Process (ELP):
- consistent with the Satellite Product and Services Review Board (SPSRB) review process
- adds value to product development
- generates standard documentation covering:
  - Requirements and Risks
  - Algorithm Theoretical Basis
  - Implementation Plan
  - Software Architecture
  - Quality Assurance
- process tailored based on implementation timeline and development progress
- tailored reviews mitigate risk by eliminating overhead of preparing multiple reviews
- technical risk is low because Level 1 and Level 2 requirements are handled by a separate review board and are already developed

Algorithm Tools

Chain run script

The Chain run script is a Perl script that automates the staging and processing of multiple SDR and EDR products. The tool, developed by STAR AIT facilitates efficient and consistent tests of interdependent algorithms.

Dark OMPS Generator Script (DOGS)

The Dark OMPS Generator Script (DOGS) is a Perl wrapper developed by the AIT to facilitate the OMPS Dark Table production process. Currently, Dark OMPS tables are generated by hand on the NASA PEAT system. DOGS will automate the table production and allow the process to transition to NASA/AVRite system. Weekly dark table updates are important for correct radiance values and accuracy of other downstream ozone/operational products which use either the OMPS Nadir Proflire (NP) or OMPS Nadir Mappre (NM).

SASQUATCH

Simplified And Streamlined Quality Assurance Through Coding Help

EPL Review documents include both Requirements Allocation Documents (RADs) and Requirements documents with identical content. Additionally, a spreadsheet is provided for review showing requirements tracing to Level 1 and Level 2 requirements. SASQUATCH is a perl script that reads requirements from a spreadsheet and generates both the RAD and Review slides, thus ensuring consistent content and formatting. EPL Review documents include a Review Item Disposition (RID) spreadsheet that tracks all risks and review items. For each review, the review items in the RID are presented. Building on the capability of SASQUATCH, Risk-SQUATCH converts the RID spreadsheet into properly formatted presentation slides for the review.

Recent DRs

STAR ASSIST regularly assists science teams with algorithm changes. Algorithm changes range from:
- We have generally worked on 30-to-40 DRs per FY.
- The current directive has emphasized KFPs. Most of our current work focuses on SDR algorithms and development and integration of J1 products. Past years have shown greater emphasis on Land, Aerosol, and Cryosphere EDRs.
- Integration and testing involves creating baseline and modified runs of test data. In cases for Cloud Mask and Aerosol changes, we diligently test the effect on downstream products using the Chainman script.

The flow chart below shows an abbreviated version of the algorithm change process. AIT provides assistance to the science team’s development of the product algorithms in the offline system. We will help science teams develop and integrate changes into ADL. We then aid in the submission process to DPER. When the updated operational algorithm is delivered, we can assist with merging the developing code with the new operational system.

The table below shows a list of DRs we have worked on and/or submitted Algorithm Change Packages (ACP) for in the past fiscal year. ACP submission is an iterative process as we work with DPER to overcome the differences between the ADL and G-ADL systems.