**MEMORANDUM FOR:** The Record

**FROM:** Dr. Alexander Ignatov

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**SUBJECT:** SST EDR Beta Status

**DATE:** 12 February 2013

The Joint Polar Satellite System (JPSS) is the follow-on to the current NOAA Polar Orbiting Environmental Satellite (POES) and NASA Earth Observing System (EOS). The Suomi National Polar-orbiting Partnership (S-NPP) Spacecraft, successfully launched on 28 October 2011, is the bridge between the POES/EOS and JPSS. The Visible Infrared Imaging Radiometer Suite (VIIRS) with 22 spectral bands covering spectral range from 0.4-12 µm succeeds the NOAA Advanced Very High Resolution Radiometer (AVHRR) and NASA Moderate Resolution Imaging Spectroradiometer (MODIS) series. Several Level 2 products (Environmental Data Records, EDR) are produced from well characterized and geo-located Level 1 radiances (Sensor Data Records, SDR).

The Sea Surface Temperature (SST) EDR is produced from three brightness temperatures (BTs) in VIIRS M bands, M12 (centered at 3.7 µm), M15 (10.8 µm), and M16 (12 µm). [Two other bands, M13 (4.05 µm) and M14 (8.55 µm), are potentially useful for SST retrievals and they will be explored later.] The SST algorithms currently employed in IDPS, are regression Non-Linear SST (NLSST) stratified by “dry” and “moist” conditions, and by day and night. The regression coefficients are explicit functions of first-guess SST (currently specified from the NCEP Global Forecast System, GFS files) and satellite view zenith angle. Separate sets of coefficients are calculated for “dry” and “moist” conditions, specified by the M15-M16 BT difference. During the daytime, SST is calculated as a combination of two BTs in bands M15 and M16. At night, M12 is additionally used. The regression coefficients are calculated using a match-up data set with quality controlled *in situ* data, which is routinely generated and updated daily at STAR.

SST retrievals are only made in cloud- and ice-free ocean pixels, identified by the VIIRS Cloud Mask (VCM) and by Cryosphere Team’s algorithms, respectively. Quality of the SST EDR is critically sensitive to the stability, accuracy and precision of the VIIRS SDRs.

Following the initial IORD and IORD-II requirements, IDPS EDR reports two SSTs in each pixel, skin and bulk. Currently, they are systematically displaced by 0.17K but identical otherwise. Per new requirements set forth in the L1RD (finalized in December 2012, currently in JPSS approval chain), only skin SST is required. Hence only skin SST will be reported in IPDS in the future once the new requirements are approved by the JPSS Program Office. Bulk SST may be derived from skin SST outside of the IDPS stream, if desired by users. The simplest proxy bulk SST can be easily estimated, as it is implemented in the current IDPS, by adding a constant +0.17K offset to the skin SST value. In this package, we only focus on the skin SST product.

In addition to the IDPS SST product, STAR has been generating an experimental VIIRS SST product using the NESDIS heritage Advanced Clear-Sky Processor for Oceans (ACSPO) system. ACSPO became operational in May 2008 with AVHRR GAC (global 4km resolution) data. Later, it has been extended to also process high-resolution data (Metop AVHRR FRAC, Terra and Aqua MODIS, SNPP VIIRS). As of this memo, 5 AVHRR GAC streams are processed at STAR (NOAA-16, -18, -19, and Metop-A and -B), 2 AVHRR FRAC (Metop-A and -B), 2 MODIS (Terra and Aqua), and SNPP VIIRS, in near-real time (2-3 days latency).

All SST products are routinely analyzed on the web in the SST Quality Monitor (SQUAM; [www.star.nesdis.noaa.gov/sod/sst/squam/](http://www.star.nesdis.noaa.gov/sod/sst/squam/)). Radiances associated with SSTs are analyzed in the Monitoring of IR Clear-sky Radiances over Oceans for SST (MICROS; [www.star.nesdis.noaa.gov/sod/sst/micros/](http://www.star.nesdis.noaa.gov/sod/sst/micros/)). The *in situ* SSTs used for routine calibration (training of SST regression coefficients) and validation (calculation of global bias and STD statistics) come from the *in situ* SST Quality Monitor (*i*Quam; [www.star.nesdis.noaa.gov/sod/sst/iquam/](http://www.star.nesdis.noaa.gov/sod/sst/iquam/)), which performs 3 functions: 1) QC of *in situ* data, 2) monitoring on the web, and 3) serving QCed *in situ* data to outside users (including SQUAM).

The ACSPO SST product and the three monitoring systems (SQUAM, MICROS, and *i*Quam) proved instrumental in evaluation of the IDPS SST product.

STAR has been continuously evaluating the IDPS SST EDR since the cryoradiator door opened on January 18, 2012, and the SST EDR product began being routinely generated by IDPS on 22 January 2012. The SST EDR data are routinely compared with ten ACSPO SST products, and one product from Metop-A FRAC AVHRR produced by the EUMETSAT Ocean and Sea Ice Satellite Operations Facility (OSI SAF) at Meteo FRANCE, Lannion, France. All SST products (including IDPS, ACSPO and OSI SAF) are uniformly validated against QCed *in situ* SST data from *i*Quam. The JPSS Algorithm Development Library (ADL) is also used to process SST data from SDR to EDR with refined algorithms and updated lookup tables (LUTs). In addition, VIIRS data have been evaluated using the results from the NAVO data processing.

Results have been presented at various JPSS meetings (including Annual Program Review Meetings in Nov’11 and Sep’12; Ocean Cal/Val Team Mtg, Stennis Center, Jan’12; SDR and VCM Beta Reviews in Apr’12; VCM Provisional Review in Jan’13; and 10+ SDR and SST Telecons), various (inter)national meetings and conferences (NASA SST Science Meeting, Miami, Nov’11; AGU, San Francisco, Dec’11; GODAE Ocean-View Coastal & Shelf Sea Task Team Workshop, Miami, Jan’12; AMS, New Orleans, Jan’12; International Space Science Inst, Geneva, Mar’12; SPIE, Baltimore, Apr’12; NPP Science Team Mtg, Greenbelt, May’12; Group for High-Res SST Mtg, Tokyo, Jun’12; IGARSS, Munich, Jul’12; Int’l Radiation Symposium, Berlin, Aug’12; SPIE, San Diego, Aug’12; EUMETSAT, Sopot, Sep’12; GSICS Annual Mtg, Beijing, Mar’12, and User’s Conf, Sep’12; SPIE, Kyoto, Nov’12). Results have been also submitted for publication in JGR (AVHRR – MODIS – VIIRS radiometric consistency for SST, Jan’13) and in JTech (destriping of VIIRS for improved SST, Feb’13). An SST algorithm paper will be also submitted for publication in the JGR JPSS special issue planned at STAR.

These evaluations and analyses, as attested in presentations and publications, suggest that as of yet, the IDPS SST product remains inferior relative to ACSPO or OSI SAF SSTs. However, itmatches reasonably well with *in situ* SSTs, and is largely consistent with ACSPO and OSI SAF SST products from various sensors and platforms.

Extensive analyses suggest that the quality of the SDR is very good and suitable for producing an accurate SST product from the VIIRS instrument. However, VCM still requires improvement. Work is underway with VCM Team.

The major areas for improvement in SST EDR to meet provisional requirements are

1. Improve performance of VCM, especially during the daytime [DR4925; DR4748];
2. Redesign of the SST EDR, including removal of the bulk SST layer [DR4789];
3. Changing SST regression formulations [DR4807]; and
4. Reorganize SST Quality Flags (QF) code [DR4790].

The corresponding DR submitted to address each area is listed in brackets. These DRs are in work.

The full list of discrepancy requests (DR) submitted to improve the SST EDR is below.

* DR4696 – fast track SST EDR Tables (DR4247, implemented)
* DR4727 – update FT VIIRS SST regression coefficients table (implemented).
* DR4748 – SST algorithm needs to check VCM quality (in progress).
* DR4789 – remove/replace bulk SST data (pending L1RD approval).
* DR4790 – SST QF code reorganization (in progress).
* DR4807 – Change form of SST equations (in progress).
* DR4844 – SZA exclusion/degradation flags affected by setting cloud/clear flags (in progress).
* DR4845 – OAD for SST does not agree with code in PCR31250 (in progress).
* DR4846 – CDFCB vol IV part 3 SZA QF definition (in progress)
* DR4925 – Unsatisfactory VCM performance for SST.

Some of these DRs have been implemented while others are work in progress and will be implemented in future IDPS builds.

Beta data quality is defined as:

* Early release product.
* Minimally validated.
* May still contain significant errors.
* Versioning not established until a baseline is determined.
* Available to allow users to gain familiarity with data formats and parameters.
* Product is not appropriate as the basis for quantitative scientific publication studies and applications.

Based on our evaluations, the SST EDR has met all these requirements and deemed ready for beta status. Despite some remaining issues, our evaluations suggest that the IDPS SST EDR product is reasonable and robust compared with *in situ* measurements, and compared with the suite of ACSPO data produced from SNPP VIIRS, as well as ACSPO and OSI SAF products produced from several AVHRR and MODIS sensors. We recommend that the IDPS SST EDR product be made publicly available, as it may be beneficial for users to start gaining experience with data formats and parameters.

The Board recommends that users be informed of the following product information and characteristics when evaluating the SST EDR:

* The SST EDR currently reports two SSTs – bulk and skin. Bulk SST = Skin SST +0.17K. Once the new L1RD requirements are approved, the bulk SST layer will be dropped and its slot will be reused to record first-guess SST. For now, users are advised to concentrate their analyses on skin SST, only.
* SST at swath edges reveals strong “limb cooling”, due to suboptimal SST equations coded in IDPS system. Revisions to SST formulations are underway, and will improve SST performance in the full VIIRS swath.
* Prior to August 10, 2012, the SST quality flags were not set correctly under certain anomalous conditions due to a bug in the code. This bug was fixed in Mx6.0, implemented into operations on August 9, 2012.
* SST Quality Flags are suboptimal and are being revisited and redesigned, and will be redefined in the future versions of the SST EDR.
* Performance of the SDRs has been verified and found very good and acceptable after the last revision to the thermal SDRs calibration on 7 March 2012.
* Performance of VIIRS Cloud Mask (VCM) remained non-uniform and suboptimal during the full monitoring period. Similar suboptimal performance issues have been observed with the VIIRS Sea Ice Concentration (SIC) algorithm as well, affecting SST (e.g., regions of ice flagged as water in high latitude regions). Fixes to both VCM and SIC are currently underway and will be reflected in future versions of the SST EDR.
* Although the SST EDR has been produced, and will be available from CLASS, since 22 January 2012, the quality is suboptimal and non-uniform. (Initially, pre-launch simulated regression coefficients were used, which were later recalculated based on real match-ups with *in situ* data, but became obsolete on 7 March 2012, due to recalibration of VIIRS SDRs in thermal bands, and recalculated later from match-ups again. Furthermore, black body warm-up/cool-down exercises in Feb 2012 resulted in large spikes in SST, up to 7K.)
* It is recommended that this non-uniformity and suboptimal quality issues should be fixed by a complete reprocessing of the full data set using uniform versions of SDR calibration, VCM and SST algorithms.

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