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# Joint Polar Satellite System (JPSS) Operational Algorithm Description (OAD) Document for VIIRS Land Surface Temperature (LST) Environmental Data Records (EDR) Software

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**Goddard Space Flight Center**
**Greenbelt, Maryland**

National Aeronautics and
Space Administration

# Joint Polar Satellite System (JPSS) Operational Algorithm Description (OAD) Document for VIIRS Land Surface Temperature (LST) Environmental Data Records (EDR) Software JPSS Electronic Signature Page

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# Preface

This document is under JPSS Ground Algorithm ERB configuration control. Once this document is approved, JPSS approved changes are handled in accordance with Class I and Class II change control requirements as described in the JPSS Configuration Management Procedures, and changes to this document shall be made by complete revision.

Any questions should be addressed to:

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# Change History Log

| Revision | Effective Date | Description of Changes<br>(Reference the CCR & CCB/ERB Approve Date) |
|---|---|---|
| Original | 06/03/2011 | This version incorporates **474-CCR-11-0113** which converts D38714, NPOESS Operational Algorithm Description Document for VIIRS Land Surface Temperature (LST) EDR, Rev B, dated 05/19/2010 to a JPSS document, Rev -. This was approved by the JPSS Ground Algorithm ERB on June 3, 2011. |
| Revision A | 01/18/2012 | **474-CCR-11-0260:** This version baselines 474-00070, Joint Polar Satellite System (JPSS) Operational Algorithm Description (OAD) Document for VIIRS Land Surface Temperature (LST) Environmental Data Records (EDR) Software, for the Mx 6 IDPS release. This CCR was approved by the JPSS Algorithm ERB on January 18, 2012. |
| Revision B | 10/09/2012 | **474-CCR-12-0627:** This version authorizes 474-00070, Joint Polar Satellite System (JPSS) Operational Algorithm Description (OAD) Document for VIIRS Land Surface Temperature (LST) Environmental Data Records (EDR) Software, for the Mx 6.1 - 6.3 IDPS releases. Includes: **ECR-ALG-0035** which contains Raytheon PCR029764; LST EDR OAD needs to be updated for QF description updated on pages 15-16. Raytheon PCR031222, OAD: Implement 474-CCR-12-0355 (Correction to LST Binary LUT File & Update to Tunable Parameter XML File) (ADR 4608), Updated Tables 3 & 9 and pages 11-12, 14-16. |
| Revision C | 05/14/2013 | **474-CCR-13-0948:** This version authorizes 474-00070, JPSS OAD Document for VIIRS LST EDR Software, for the Mx 7.0 IDPS release. Includes Raytheon PCR032720; 474-CCR-13-0916/ECR-ALG-0037: Update applicable OAD filenames/template/Rev/etc. for Mx7 Release. |
| Revision D | 11/06/2013 | **474-CCR-13-1288:** This version authorizes 474-00070, JPSS OAD Document for VIIRS LST EDR Software, for Mx 8.0 IDPS release. Includes administrative changes authorized by interoffice memo and Raytheon PCR034406; OAD: PRO: 474-CCR-13-1056: Error in LST OAD (DR7203), in section 2.1.4. |



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# NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS)

# OPERATIONAL ALGORITHM DESCRIPTION DOCUMENT FOR VIIRS LAND SURFACE TEMPERATURE (LST) EDR

## SDRL No. S141
## SYSTEM SPECIFICATION SS22-0096

**RAYTHEON COMPANY**
**INTELLIGENCE AND INFORMATION SYSTEMS (IIS)**
**NPOESS PROGRAM**
**OMAHA, NEBRASKA**

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TITLE: NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS) OPERATIONAL ALGORITHM DESCRIPTION DOCUMENT FOR VIIRS LAND SURFACE TEMPERATURE

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**Acquisition & Operations Contract**

**CAGE NO. 11982**

# Operational Algorithm Description
# VIIRS Land Surface Temperature (LST) EDR

**Document Number: D38714**
**Document Date: Sep 19, 2011** **Revision: C4**

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This document has been identified per the NPOESS Common Data Format Control Book – External Volume 5 Metadata, D34862-05, Appendix B as a document to be provided to the NOAA Comprehensive Large Array-data Stewardship System (CLASS) via the delivery of NPOESS Document Release Packages to CLASS.



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## Revision/Change Record

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|---|---|---|---|
| --- | 3-30-04 | Initial Release. | All |
| A1 | 2-22-05 | Reflects Science To Operational Code Conversion. | Pg 2 |
| A2 | 8-31-05 | Minor Edits On-Going. Implemented TM NP-EMD.2004.510.0047 in B1.3. | All |
| A3 | 7-27-07 | Updated to match ops code. | All |
| A4 | 8-2-07 | TMs NP-EMD-2006.510.0081, NP-EMD.2005.510.0132, NP-EMD.2005.510.0133, and NP-EMD.2006.510.0010 have been implemented in B1.5. Delivered to NGST. | All |
| A5 | 12-10-07 | ECR A-103, EDRPR 1.8 CP 3 updates -Format changes for CDFCB-X compliance - Remove LST Granule Level QF Output and Description. | All |
| A6 | 9-12-08 | Reformatted document to implement template D41851 format. Modified graceful degradation and data quality notification sections. New cover sheet, update references, acronym list, prepare for peer review. Delivered to NGST. | All |
| A7 | 9-15-08 | Implemented TM NP-EMD-2008.510.0021 | 8, 12, 13 |
| A8 | 12-9-08 | Addressed NGST comments from last delivery. | All |
| A9 | 2-18-09 | Added Thin Cirrus quality flag to Quality Byte 0 (PCR019663)<br><br>Updated for TIM | Tables 6, 8, & 9<br>All |
| A | 3-18-09 | Incorporated TIM comments and final preparation for ARB/ACCB. | All |
| B1 | 11-04-09 | Incorporated RFA No. 376 and updated for SDRL | All |
| B2 | 3-3-10 | NP-EMD.2009.510.0077_LST_v4.15.1_OAD_Updates-RevB.DOC | All |
| B | 5-19-10 | Prepared for TIM/ARB/ACCB | All |
| C1 | 8-18-10 | Updated Table 1 & 2 due to omission of TM 2010.510.0005.Rev-C | Table 1 & 2 |
| C2 | 8-27-10 | ECR1061/PCR024068 update output range values | Table 7 |
| C3 | 10-14-10 | Updated due to document convergence, to include tech memo 2010.510.0013 | All |
| C4 | 9-19-11 | Updated for PCRs 025898, 026163 and 027081 | 5, 7, 11-12, 14 18 |



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# 1.0 INTRODUCTION

## 1.1 Objective

The purpose of the Operational Algorithm Description (OAD) document is to express, in computer-science terms, the remote sensing algorithms that produce the National Polar-Orbiting Operational Environmental Satellite System (NPOESS) end-user data products. These products are individually known as Raw Data Records (RDRs), Temperature Data Records (TDRs), Sensor Data Records (SDRs) and Environmental Data Records (EDRs). In addition, any Intermediate Products (IPs) produced in the process are also described in the OAD.

The science basis of an algorithm is described in a corresponding Algorithm Theoretical Basis Document (ATBD). The OAD provides a software description of that science as implemented in the operational ground system -- the Data Processing Element (DPE).

The purpose of an OAD is two-fold:

1. Provide initial implementation design guidance to the operational software developer.
2. Capture the “as-built” operational implementation of the algorithm reflecting any changes needed to meet operational performance/design requirements.

An individual OAD document describes one or more algorithms used in the production of one or more data products. There is a general, but not strict, one-to-one correspondence between OAD and ATBD documents.

## 1.2 Scope

The scope of this document is limited to the description of the core operational algorithm required to create the VIIRS Land Surface Temperature (LST) EDR. The theoretical basis for this algorithm is described in Section 3.3 of VIIRS Land Surface Temperature Algorithm Theoretical Basis Document ATBD, 474-00051.

## 1.3 References

### 1.3.1 Document References

The science and system engineering documents relevant to the algorithms described in this OAD are listed in Table 1.

**Table 1. Reference Documents**

| Document Title | Document Number/Revision | Revision Date |
| --- | --- | --- |
| VIIRS Land Surface Temperature Algorithm Theoretical Basis Document ATBD | 474-00051 | Latest |
| VIIRS Radiometric Calibration Algorithm Theoretical Basis Document ATBD | 474-00027 | Latest |
| VIIRS Surface Temperature Module Level Software Architecture | Y2473 Ver. 5 Rev. 12 | 30 Jul 2004 |
| VIIRS Surface Temperature Module-Level Interface Control | Y3281 Ver. 5 Rev. 4 | Dec 2003 |



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| Document Title | Document Number/Revision | Revision Date |
|---|---|---|
| Document | | |
| VIIRS Surface Temperature Module Level Data Dictionary | Y0011652 Ver. 5 Rev. 3 | Dec 2003 |
| VIIRS Land Surface Temperature Unit Level Detailed Design | Y2502 Ver. 5.1 Rev. 5 | 25 Jun 2004 |
| VIIRS Radiometric Calibration Unit Level Detailed Design | Y2490 Ver. 5 Rev. 4 | 30 Sep 2004 |
| Operational Algorithm Description Document for VIIRS Cloud Mask Intermediate Product (VCM IP) | 474-00062 | Latest |
| Operational Algorithm Description Document for VIIRS Aerosol Products (AOT, APSP & SM) Intermediate Product (IP)/Environmental Data Records (EDR) | 474-00073 | Latest |
| Operational Algorithm Description Document for Common Geolocation | 474-00091 | Latest |
| Operational Algorithm Description Document for VIIRS Geolocation (GEO) Sensor Data Record (SDR) and Calibration (CAL) SDR | 474-00090 | Latest |
| Operational Algorithm Description Document for VIIRS Surface Type (STYP) Environmental Data Records (EDR) | 474-00068 | Latest |
| JPSS Environmental Data Record (EDR) Production Report (PR) for NPP | 474-00012 | Latest |
| JPSS Environmental Data Record (EDR) Interdependency Report (IR) for NPP | 474-00007 | Latest |
| NPP Mission Data Format Control Book and App A (MDFCB) | 429-05-02-42_MDFCB | Latest |
| JPSS Common Data Format Control Book - External - – Block 1.2.2 (All Volumes) | 474-00001-01-B0122 CDFCB-X Vol I<br>474-00001-02-B0122 CDFCB-X Vol II<br>474-00001-03-B0122 CDFCB-X Vol III<br>474-00001-04-01-B0122 CDFCB-X Vol IV Part 1<br>474-00001-04-02-B0122 CDFCB-X Vol IV Part 2<br>474-00001-04-03-B0122 CDFCB-X Vol IV Part 3<br>474-00001-04-04-B0122 CDFCB-X Vol IV Part 4<br>474-00001-05-B0122 CDFCB-X Vol V<br>474-00001-06-B0122 CDFCB-X Vol VI<br>474-00001-08-B0122 CDFCB-X Vol VIII | Latest |
| JPSS Common Data Format Control Book - External - Block 1.2.3 (All Volumes) | 474-00001-01-B0123 CDFCB-X Vol I<br>474-00001-02-B0123 CDFCB-X Vol II<br>474-00001-03-B0123 CDFCB-X Vol III<br>474-00001-04-01-B0123 CDFCB-X Vol IV Part 1<br>474-00001-04-02-B0123 | Latest |

| Document Title | Document Number/Revision | Revision Date |
|---|---|---|
| | CDFCB-X Vol IV Part 2<br>474-00001-04-03-B0123 CDFCB-X Vol IV Part 3<br>474-00001-04-04-B0123 CDFCB-X Vol IV Part 4<br>474-00001-05-B0123 CDFCB-X Vol V<br>474-00001-06-B0123 CDFCB-X Vol VI<br>474-00001-08-B0123 CDFCB-X Vol VIII | |
| NPP Command and Telemetry (C&T) Handbook | D568423 Rev. C | 30 Sep 2008 |
| JPSS CGS Data Processor Inter-subsystem Interface Control Document (DPIS ICD) Vol I – IV | IC60917-IDP-002 | Latest |
| IDPS Processing SI Common IO Design Document | DD60822-IDP-011 Rev. A | 21 Jun 2007 |
| Joint Polar Satellite System (JPSS) Program Lexicon | 470-00041 | Latest |
| NGST/SE technical memo – LST OAD Update | NP-EMD.2004.510.0047 | 19 Nov 2004 |
| NGST/SE technical memo – NPP_VIIRS_IST_LST_STIP_BugsFix | NP-EMD-2006.510.0081 | 31 Oct 2006 |
| NGST/SE technical memo – LST OAD Update_Drop2.5.2 | NP-EMD.2005.510.0132 | 21 Oct 2005 |
| NGST/SE technical memo – LST_Drop2.5.2_UT | NP-EMD.2005.510.0133 | 21 Oct 2005 |
| NGST/SE technical memo – NPP_VIIRS_LST_QFFillValues_SPCR_ALG979 | NP-EMD.2006.510.0010 | 30 Jan 2006 |
| NGST/SE technical memo – VIIRS IST EDR and LST EDR AOT Exclusion Implementation | NP-EMD-2006.510.0097, RevB | 07 Feb 2007 |
| NGST/SE technical memo – VIIRS LST Quality Flags Update | NP-EMD.2008.510.0021 | 15 Apr 2008 |
| JPSS Data Format Control Book – Internal Volume III – Retained Intermediate Product Formats (IDFCB) – Block 1.2.3 | 474-00020-03-B0123 IDFCB Vol III | Latest |
| NGST/SE technical memo – NPP_LST_DegradQF&SurfTypeDefUpdate | NP-EMD.2008.510.0053_RevB | 29 May 2009 |
| NGAS/A&DP technical memo – LST_v4.15.1_Code_Updates-RevA | NP-EMD.2009.510.0076 | 15 Dec 2009 |
| NGAS/A&DP technical memo – LST_v4.15.1_OAD_Updates-RevB | NP-EMD.2009.510.0077 | 23 Dec 2009 |
| NGST/SE technical memo – Granule-Level Summary Exclusion Flag Definition Rev. C | NP.EMD.2010.510.0005.Rev-C | 02 Mar 2010 |
| NGST/SE technical memos: PC_OAD_Last_Drop_Corrections | NPOESS GJM-2010.510.0013 | 22 Sep 2010 |
| NGST/SE technical memo – LST Baseline Algorithm Mode Switch Setting Instructions | NP.EMD.2010.510.0098 | 22 Dec 2010 |
| NGST/SE technical memo – LST OAD Update for baseline algorithm mode switch setting | NP.EMD.2010.510.0099 | 22 Dec 2010 |

### 1.3.2 Source Code References

The science and operational code and associated documentation relevant to the algorithms described in this OAD are listed in Table 2.

**Table 2. Source Code References**

| Document Title | Reference Tag/Revision | Revision Date |
|---|---|---|
| VIIRS LST Science-grade Software | 2.01 | Jan 2006 |
| VIIRS LST Operational Software | B1.5 (OAD Rev A4) | Jul 2007 |
| NGST/SE technical memo – NPP_VIIRS_IST_LST_STIP_BugsFix | NP-EMD-2006.510.0081 | 31 Oct 2006 |
| NGST/SE technical memo – LST_Drop2.5.2_UT | NP-EMD.2005.510.0133 | 21 Oct 2005 |
| NGST/SE technical memo – NPP_VIIRS_LST_QFFillValues_SPCR_ALG979 | NP-EMD.2006.510.0010 | 30 Jan 2006 |
| NGST/SE technical memo – VIIRS LST Quality Flags Update | NP-EMD.2008.510.0021 | 15 Apr 2008 |
| VIIRS LST Operational Software | Build 1.5.x.1-L (PCR019663) (OAD Rev A9) | 18 Feb 2009 |
| VIIRS LST Science-grade Software Includes TM: NP-EMD.2008.510.0021_NPP_LST_QualityFlagsUpdate | ISTN_VIIRS_NGST_2.5.5_DATA (ECR A-145) | 21 May 2008 |
| VIIRS LST Science-grade Software | ISTN_VIIRS_NGST_2.5.6_DATA | 16 Apr 2009 |
| VIIRS LST Science-grade Software | ISTN_VIIRS_NGST_4.15 | 27 May 2009 |
| ACCB (no code update) | OAD Rev A | 18 Mar 2009 |
| SDRL (no code update) | OAD Rev B1 | 04 Nov 2009 |
| VIIRS LST Science-grade Software<br>Includes NGAS/A&DP technical memos –<br>LST_v4.15.1_Code_Updates-RevA.DOC NP-EMD.2009.510.0076 (PCR 022280)<br>LST_v4.15.1_OAD_Updates-RevB.DOC NP-EMD.2009.510.0077 (PCR 022281) | ISTN_VIIRS_NGST_4.15.1 (ECR A-264) | 11 Jan 2010 |
| VIIRS LST Operational Software Includes PCRs 22280 & 22281 | Sensor Characterization (Build SC-8) (OAD Rev B2) | 02 Mar 2010 |
| PCR 21488 [TM 2010.510.0005.Rev-C ] (No OAD update required) | Build Sensor Characterization SC-09 | 05 Apr 2010 |
| ACCB | OAD Rev B | 19 May 2010 |
| ECR1061/PCR024068 update output range values | (OAD Rev C2) | 27 Aug 2010 |
| Convergence Updates (No code updates) | (OAD Rev C3) | 14 Oct 2010 |
| VIIRS LST Science-grade Software<br>Includes NGAS/A&DP technical memos –<br>LST Baseline Algorithm Mode Switch Setting Instructions)<br>LST OAD Update for Baseline Algorithm Mode Switch Setting Instructions | ISTN_VIIRS_NGST_4.15.2 (ECR Alg-0004) | 13 Jan 2011 |
| VIIRS LST Operational Software<br>PCR025898 (TM 2010.510.0098) | Build Maintenance Release 1.05.06-F | 02 Aug 2011 |
| PCRs 026163 (TM 2010.510.0099) and 027081 (x-ref PCR025632) | (OAD Rev C4) | 19 Sep 2011 |
| OAD transitioned to JPSS Program – this table is no longer updated. | | |

## 2.0 ALGORITHM OVERVIEW

The purpose of the LST Module is to retrieve the LST for each cloud-free land pixel at VIIRS moderate-resolution. Brightness temperature data from the VIIRS SDR, VIIRS Aerosol Optical Thickness (AOT) Intermediate Product (IP), VIIRS Cloud Mask (VCM) IP, and VIIRS Surface Type (STYP) EDR are used to decide whether the pixel is processed. A 2-band single split-window algorithm is the operational baseline algorithm and a 4-band dual split-window algorithm is available as an optional algorithm. LST is retrieved using a regression equation with separate coefficients for each of the 17 International Geosphere-Biosphere Program (IGBP) land cover types. Moderate resolution pixel level LST in Kelvin and the associated 3-byte LST quality information are written to the VIIRS LST EDR. The LST Processing Chain is shown in Figure 1.

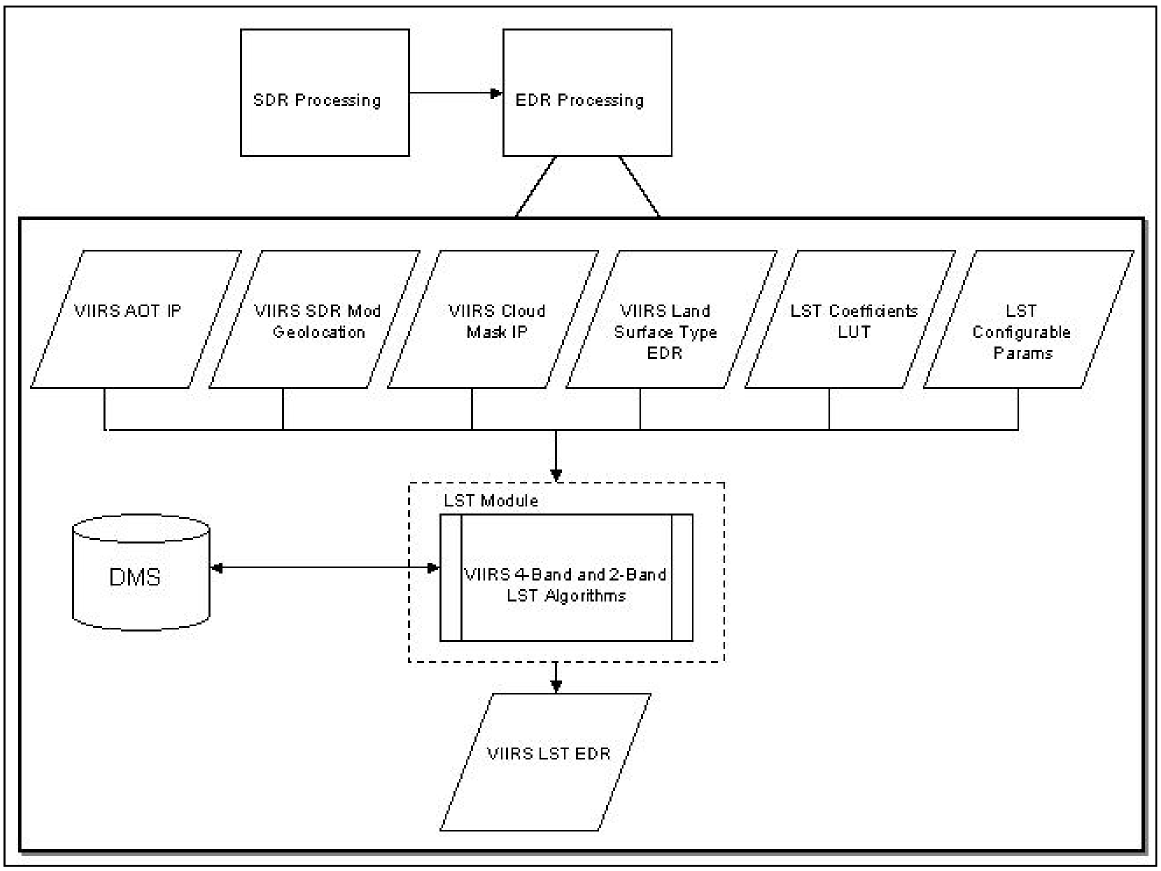


**Figure 1. LST Processing Chain**

### 2.1 Land Surface Temperature EDR Description

The VIIRS Land Surface Temperature Algorithm Theoretical Basis Document ATBD, 474-00051, describes in detail the VIIRS LST retrieval algorithm.



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### 2.1.1 Interfaces

To begin data processing, the Infrastructure (INF) Subsystem Software Item (SI) initiates the LST algorithm. The INF SI provides tasking information to the algorithm indicating which granule to process. The Data Management Subsystem (DMS) SI provides data storage and retrieval capability. A library of C++ classes implements the SI interfaces, depicted in Figure 2.

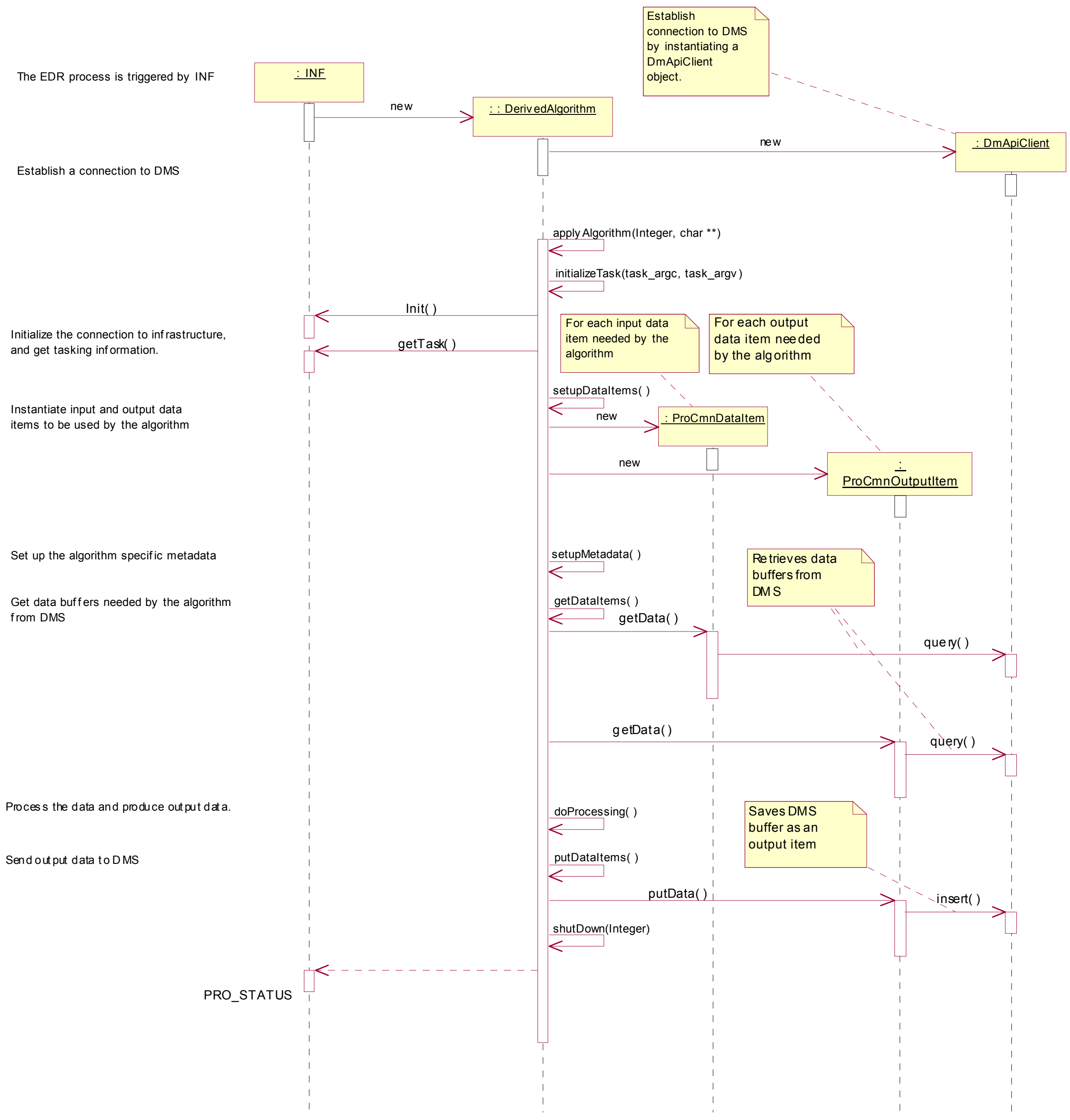


**Figure 2. IPO Model Interface to INF and DMS**



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#### 2.1.1.1 Inputs

Refer to the CDFCB-X, 474-00001, for a detailed description of the inputs. For the AOT parameter format, refer directly to Volume III of the IDFCB, 474-00020. All temperatures are expressed in Kelvin (K) units. Table 3 shows the LST main inputs and Table 4 shows the LST EDR Auxiliary / Ancillary data inputs.

**Table 3. LST Main Inputs**

| Input | Type | Description | Units/Valid Range |
|---|---|---|---|
| BT_M12 | Float32 | Brightness Temperature of Band M12 | K / Please refer to VIIRS Radiometric Calibration ATBD, 474-00027 |
| BT_M13 | Float32 | Brightness Temperature of Band M13 | K / Please refer to VIIRS Radiometric Calibration ATBD, 474-00027 |
| BT_M15 | Float32 | Brightness Temperature of Band M15 | K / Please refer to VIIRS Radiometric Calibration ATBD, 474-00027 |
| BT_M16 | Float32 | Brightness Temperature of Band M16 | K / Please refer to VIIRS Radiometric Calibration ATBD, 474-00027 |
| VIIRS SDR MOD geolocation Data | Float32 | VIIRS SDR MOD geolocation structure / -Sensor Zenith Angle -Solar Zenith Angle | Sensor Zenith Angle degree / $0^o \leq$ SenZenAngle $\leq 71.62^o$ |
| | | | Solar Zenith Angle degree / $0^o \leq$ SolZenAngle $\leq 180^o$ |
| | | | Latitude degree/ Used to determine ellipsoid fill |
| VIIRS Cloud Mask IP | Uint8 | VIIRS_CLOUD_MASK_IP_TYPE Land/Water Background Flag | Unitless / 000 = Land & Desert 001 = Land no Desert 010 = Inland Water 011 = Sea Water 101 = Coastal |
| | | Day/Night Flag | Unitless / 0 = Night 1 = Day |
| | | Confidence Indicator | Unitless / 11 = Confident Cloudy 10 = Probably Cloudy 01 = Probably Clear 00 = Confident Clear |

| Input | Type | Description | Units/Valid Range |
|---|---|---|---|
| | | Sun Glint Flag | Unitless /<br>00 = None<br>01 = Geometry Based<br>10 = Wind Speed Based<br>11 = Geometry & Wind |
| | | Thin Cirrus | Unitless /<br>0 = No<br>1 = Yes |
| VIIRS Land Surface Type EDR | Uint8 | VIIRS_Surface_Type_EDR_Type<br>Surface Type Flag<br><br>Fire Flag<br><br>Snow Cover Flag | Unitless /<br>Valid Range: 1 to 17,<br>0 = Invalid<br>1 = Evergreen Needleleaf Forests<br>2 = Evergreen Broadleaf Forests<br>3 = Deciduous Needleleaf Forests<br>4 = Deciduous Broadleaf Forests<br>5 = Mixed Forests<br>6 = Closed Shrublands<br>7 = Open Shrublands<br>8 = Woody Savannas<br>9 = Savannas<br>10 = Grasslands<br>11 = Permanent Wetlands<br>12 = Croplands<br>13 = Urban and Built-Up Lands<br>14 = Cropland/Natural Vegetation Mosaics<br>15 = Snow and Ice<br>16 = Barren<br>17 = Water Bodies<br>18-31 = Invalid<br><br>Unitless /<br>0 = No Fire<br>1 = Active Fire<br><br>Unitless /<br>0 = No Snow<br>1 = Snow Cover |
| VIIRS Aerosol Optical Thickness | Float32 | VIIRS_AOT_IP_TYPE<br>Aerosol Optical Thickness at 550 nm (slant path) | Unitless<br>AOT ≥ 0 |
| VIIRS_LST_LUT | Float64 | viirs_Lst_Coeffs_LUT<br>term: dual window[9], split - window[5]<br>Indices representing coefficients a0… a8 | Term<br>Unitless |
| | | daynight[2] Key to LUT daynight dimension | Unitless /<br>0 = night<br>1 = day |

| Input | Type | Description | Units/Valid Range |
|---|---|---|---|
| | | surfacetype[17]<br>IGBP Surface Types<br>Land Surface Type EDR | Unitless /<br>0 to 16 |
| | | algorithm[2]<br>Key to LUT algorithm dimension | Unitless /<br>0 = “dual”<br>1 = “split” |
| | | regime[1]<br>This is a placeholder only (not used) | Unitless /<br>regime = 0 |
| VIIRS_LST_COEFFICIENTS | Float32 | Structure containing all configurable parameters for LST<br><br>min_Bt_M12_M13 | <br><br><br>180 K |
| | | max_Bt_M12_M13 | 350 K |
| | | min_Bt_M15 | 180 K |
| | | max_Bt_M15 | 350 K |
| | | min_Bt_M16 | 180 K |
| | | max_Bt_M16 | 350 K |
| | | day_Sol_Zen_Ang_Lim | 1.4835 Radians |
| | | min_Sens_Zen_Lim | 0.0 Radians |
| | | Max_Sens_Zen_Lim | 0.8779 Radians |
| | | min_Term_Lim | 1.4835 Radians |
| | | max_Term_Lim | 1.7453 Radians |
| | | lstMinTemp | 183.5 K |
| | | lstMaxTemp | 348 K |
| | | max_Sens_Zen_Lim | 0.6981 Radians |
| LST Data Quality Notification | Structure | Reports erroneous pixels through a DQN | -999.71 to<br>–999.69<br>Check for<br>–999.7 is needed |

**Table 4. LST EDR Auxiliary / Ancillary Data Inputs**

| Input | Type | Description/Source | Units/Valid Range |
|---|---|---|---|
| Solar Zenith Angle | Float32 | VIIRS SDR MOD | Radians / 0 to π |
| Sensor Zenith Angle | Float32 | VIIRS SDR MOD | Radians / 0 to 1.25 |

### 2.1.1.2 Outputs

Primary outputs of the LST algorithm, as shown in Table 5, are a temperature value and a 3-byte LST quality flag (QF) for each moderate resolution pixel. For a description of the file metadata please reference Volume V of the CDFCB-X, 474-00001. Refer to the CDFBC-X, 474-00001, Vol. VI, Part 3, for a detailed description of the outputs.

The LST field in the EDR is scaled to fit into a Uint16 from calculated Float32 value.

**Table 5. Output LST EDR Content**

| Output | Data Type/Size | Description | Units / Valid Range |
|---|---|---|---|
| Land Surface Temperature | Uint16 | LST is determined for each pixel in the granule. The output is to be scaled so it will fit into a Uint16. | Scaled Kelvin / 0 to 65527 (Unscaled range: 183.2 K to 350.0 K) |
| Land Surface Temperature Quality Byte 0 | Uint8 | Two-dimensional array of M_VIIRS_SDR_ROWS by M_VIIRS_SDR_COLS of Quality. Assurance bitmap with test information for each pixel in the granule. (See Table 6.) | Unitless / None |
| Land Surface Temperature Quality Byte 1 | Uint8 | Two-dimensional array of M_VIIRS_SDR_ROWS by M_VIIRS_SDR_COLS of Quality. Assurance bitmap with test information for each pixel in the granule. (See Table 6.) | Unitless / None |
| Land Surface Temperature Quality Byte 2 | Uint8 | Two-dimensional array of M_VIIRS_SDR_ROWS by M_VIIRS_SDR_COLS of Quality. Assurance bitmap with test information for each pixel in the granule. (See Table 6.) | Unitless / None |
| lstScale | Float32 | The scale value for the Land Surface Temperature. This can be found by subtracting the minimum acceptable temperature of 183.2 K from the maximum of 350.0 K and dividing this result by 65527. The maximum and minimum temperatures are configurable. | Unitless / None |
| lstOffset | Float32 | The offset value is the minimum acceptable temperature of the LST. The minimum temperature is 183.2 K and it is configurable. | Unitless / None |

**Table 6. LST Pixel Level QF Output Bits and Descriptions**

| Byte | Bit | Flag Description Key | Result |
|---|---|---|---|
| 0 | 0-1 | LST Quality | Bit 1 Bit 0<br>0 0 = High<br>0 1 = Medium<br>1 0 = Low<br>1 1 = No Retrieval |
| | 2 | Algorithm | 0 = 4-band dual-split window<br>1 = 2-band split-window |
| | 3 | Day/Night | 0 = Night<br>1 = Day, ($0^o \leq$ Solar Zenith Angle $\leq 85^o$) |
| | 4 | SWIR (M12 and M13) Brightness Temperatures availabilities | 0 = both available<br>1 = at least one not available |
| | 5 | LWIR (M15 and M16) Brightness Temperatures availabilities | 0 = both available<br>1 = at least one not available |
| | 6 | Active Fire | 0 = no active fire<br>1 = active fire |
| | 7 | Exclusion – Thin Cirrus | 0 = no thin cirrus<br>1 = thin cirrus |
| 1 | 0 | Clear Measurement Precision Degradation– | 0 = no degradation<br>1 = degradation |


Check the JPSS MIS Server at https://jpssmis.gsfc.nasa.gov/frontmenu_dsp.cfm to verify that this is the correct version prior to use.

| Byte | Bit | Flag Description Key | Result |
|---|---|---|---|
| | 1 | Retrieved LST out of expected reporting range | 0 = within range, (213 K ≤ *LST* ≤ 343 K)<br>1 = out of range |
| | 2-3 | Cloud Confidence Indicator | Bit 1 Bit 0<br>0 0 = Confidently Clear<br>0 1 = Probably Clear<br>1 0 = Probably Cloudy<br>1 1 = Confidently Cloudy |
| | 4 | AOT Condition | 0 = within range, (AOT ≤ 1.0)<br>1 = outside range |
| | 5 | Horizontal Reporting Interval | 0 = within Horizontal Cell Size, Nadir to 1.3 km<br>($0^o$ ≤ Sensor Zenith Angle ≤ $53^o$)<br>1 = out of range |
| | 6 | Sun Glint | 0 = None<br>1 = Present |
| | 7 | Terminator | 0 = Beyond Terminator<br>1 = Inside Terminator,<br>($85^o$ < Solar Zenith Angle ≤ $100^o$) |
| 2 | 0-2 | Land/Water Background | Bit 2 Bit 1 Bit 0<br>0 0 0 = Land and Desert<br>0 0 1 = Land / No Desert<br>0 1 0 = Inland Water<br>0 1 1 = Sea Water<br>1 0 1 = Coastal |
| | 3-7 | Surface Type | 00001 = Evergreen Needleleaf Forests<br>00010 = Evergreen Broadleaf Forests<br>00011 = Deciduous Needleleaf Forests<br>00100 = Deciduous Broadleaf Forests<br>00101 = Mixed Forests<br>00110 = Closed Shrublands<br>00111 = Open Shrublands<br>01000 = Woody Savannahs<br>01001 = Savannahs<br>01010 = Grasslands<br>01011 = Permanent Wetlands<br>01100 = Croplands<br>01101 = Urban Built-Up<br>01110 = Croplands/Natural Vegetation Mosiacs<br>01111 = Snow Ice<br>10000 = Barren<br>10001 = Water Bodies<br>11111 = Invalid IGBP Surface Type |


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### 2.1.2 Algorithm Processing

The objective of the LST algorithm is to calculate LST at each pixel in a moderate resolution (750 m) granule with all available input. Two similar regression algorithms are used to perform this retrieval:

1) The operational baseline algorithm is the 2-band split-window algorithm where only the LWIR band pair M15 and M16 are used. The 2-band split-window algorithm is set as the baseline operatonal algorithm by a run time switch.

2) A 4-band dual-split window algorithm is available as an optional algorithm that uses brightness temperatures from two pair of VIIRS wavebands—one pair in the Medium-Wavelength Infrared (MWIR) atmospheric window (Bands M12 and M13) and the other pair in the Long-Wavelength Infrared (LWIR) atmospheric window (Bands M15 and M16), and Quality assessment flags for each pixel are stored in the LST Flag output..

#### 2.1.2.1 Main Module – RetrieveLst

#### 2.1.2.2 LST Retrieval Logic

The logic flow of the LST retrieval algorithm is provided in Figure 3. The core logic occurs in two functions, `setLstQualFlags()` and `calculateLst()`. In the current implementation, LST QFs additionally serve as decision flags. Their values are used in the decision of whether LST can be retrieved and, if so, which algorithm to use.


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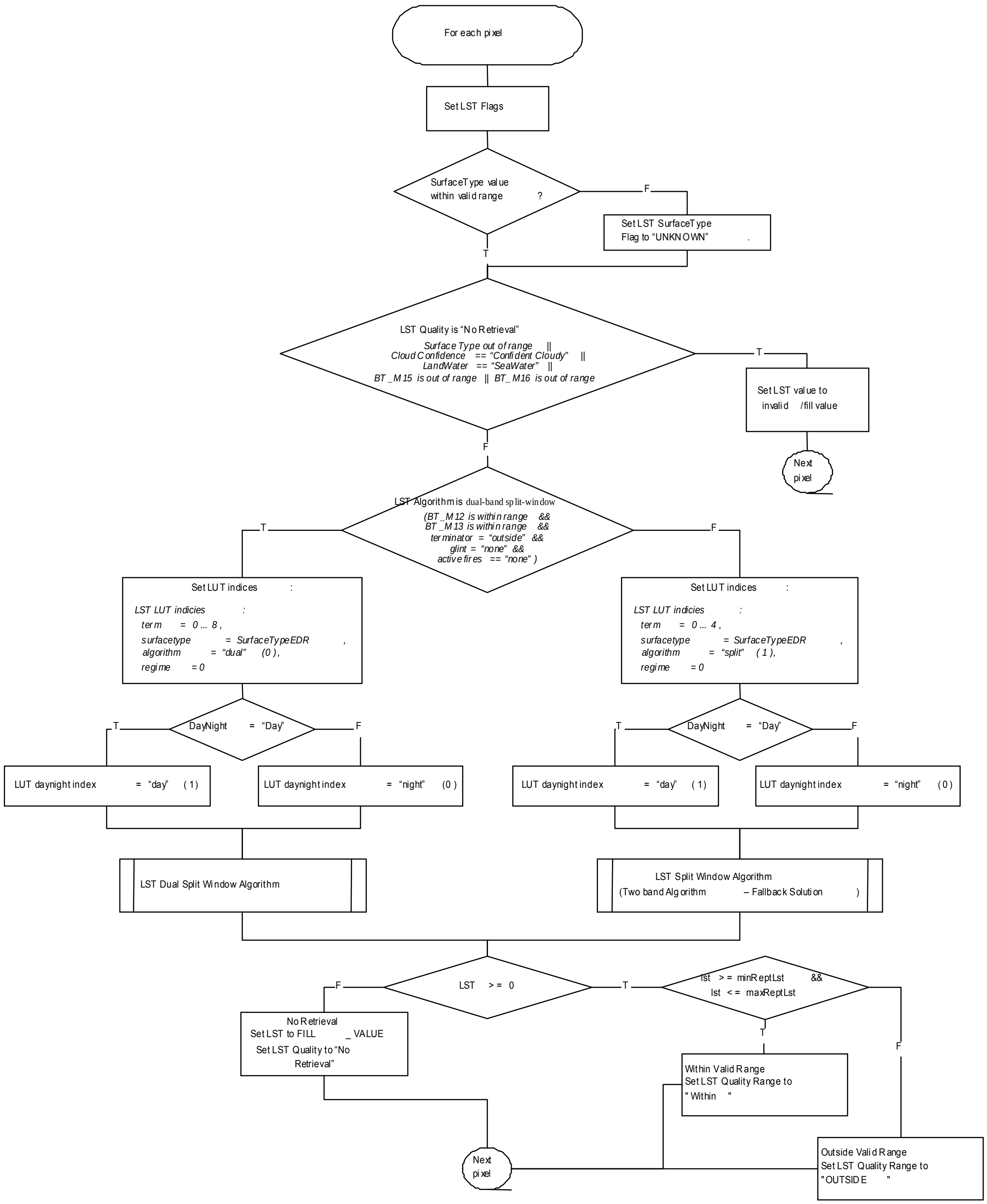


**Figure 3. LST Retrieval Logic Flow**

LST is not retrieved if any of the following conditions occur:

- The pixel is cloudy (i.e., Cloud Confidence Flag is "Confidently Cloudy"), or
- The pixel is an ocean pixel (i.e., LandWater Flag is "SeaWater"), or
- Band M15 brightness temperature is outside the LST defined range, or
- Band M16 brightness temperature is outside the LST defined range, or
- Land STYP is outside the LST defined range.

These pixels are marked with an LST QF of "No Retrieval" and are output with fill values.

For pixels that are processed, LST is retrieved by either the 2-band, split-window algorithm or an optional 4-band dual split window algorithm. The 2-band split-window algorithm is used as the operational baseline algorithm. The optional 4-band, dual split-window algorithm is available but may be used only under optimal conditions: no solar glint, no active fires, outside the terminator, and "in-range" brightness temperatures for the M12 and M13 bands. If the 4-band dual split-window algorithm is optionally invoked the algorithm will automatically revert to the split-window algorithm for non-optimal conditions. See Table 9, Section 2.1.2.3, for the logic to algorithm is used. The 2-band, split window algorithm is set as the operational baseline algorithm by a run time algorithm mode switch (*algmode*). A switch value of "1" specifies that the 2-band split window algorithm will be used as the baseline operational algorithm. A switch value of "0" specifies that the optional dual split-window algorithm is to be used. The run time algorithm mode switch should be set to 1 as the default run mode for initial operations at IDPS, corresponding to use of the 2-band split-window algorithm as the baseline algorithm. Determination of whether the 2-band split-window LST algorithm should remain as the baseline algorithm will be made during calibration/validation of the LST algorithm. If it is determined as a result of performance evaluated during calibration/validation that the 2-band split window algorithm should no longer be the baseline algorithm then the algorithm mode switch should be set to 0 resulting in the 4-band, dual split-window algorithm being used.

Core equations for the dual-band split-window and split-window fallback algorithms are specified in Table 10. The implementation is presented in `calculateLst()`. The daytime dual-band split-window algorithm varies slightly from its nighttime counterpart in that a solar zenith angle correction is made for the daytime retrieval.

For an off-nominal condition where a negative LST is retrieved, the LST field is filled and the LST quality bit field is set to "No Retrieval".

Table 7 contains the list of configurable algorithm parameters.

**Table 7. List of Configurable Algorithm Parameters**

| Algorithm Parameter | Description | Assigned Values |
|---|---|---|
| LST_MIN_M12_M13_BT | Minimum brightness temperatures for M12 and M13 | 180 K |
| LST_MAX_M12_M13_BT | Maximum brightness temperatures for M12 and M13 | 350 K |
| LST_MIN_M15_BT | Minimum brightness temperature for M15 | 180 K |
| LST_MAX_M15_BT | Maximum brightness temperature for M15 | 350 K |
| LST_MIN_M16_BT | Minimum brightness temperature for M16 | 180 K |
| LST_MAX_M16_BT | Maximum brightness temperature for M16 | 350 K |



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| Algorithm Parameter | Description | Assigned Values |
|---|---|---|
| LST_DAYNIGHT_SOL_ZEN_LIMIT | Solar zenith angle defining day/night boundary | 1.4835 Radians |
| LST_MIN_HCS_SENS_ZEN_LIMIT | Sensor zenith angle at Nadir * PI/180 | 0.0 Radians |
| LST_MAX_HCS_SENS_ZEN_LIMIT | Sensor zenith angle at the edge of scan | 0.8779 Radians |
| LST_MIN_TERMINATOR_LIMIT | Minimum solar zenith angle defines the terminator region | 1.4835 Radians |
| LST_MAX_TERMINATOR_LIMIT | Maximum solar zenith angle defines the terminator region | 1.7453 Radians |
| lstMinTemp | Minimum reported temperature | 183.20K |
| lstMaxTemp | Maximum reported temperature | 350K |
| Algmode | 0 equals dual mode, 1 equals splt mode | 0 |

### 2.1.2.3 LST Quality Flag Logic

The LST Flags consist of three 8-bit words and are shown in Table 8. The logic to set these flags is performed in function `setLstQualFlags()` and provided in Table 8 and Table 9.

Overall LST pixel quality is represented by the quality bit field. Pixel quality is flagged as "No Retrieval" and the corresponding LST will be filled:

(BT_M15 is outside range) or (BT_M16 is outside range) or
(Cloud Confidence is "Confidently Cloudy") or (STYP is outside range) or
(LandWater Flag is "SeaWater")

LST < 0 (determined after attempt is made to retrieve LST).

Note regarding the Sfc Type QF: The Sfc Type EDR has an array of surface types granulated from the IGBP Sfc Type tiles. However, when that array is copied into the LST EDR Sfc Type qf it is further modified by the Sfc Type EDR snow/ice qf to be snow/ice if that qf was triggered. That Sfc Type EDR snow/ice qf is triggered if the binary snow map EDR input is available (binary snow map is day only, not conf cloudy, sza<85 deg) and greater than a threshold (0.5). If that qf is not triggered, then the surface type in the LST EDR sfc type qf will remain the same as given in the Sfc Type EDR.

The logic to set the bit field under various retrieval conditions is shown in Table 9.

**Table 8. LST QF Logic**

| LST Flag | Input Source | Flag Setting |
|---|---|---|
| Band M12 Brightness Temperature Quality | viirs_mod_SDR_bt_type | if (180 K < $BT_{M12}$ < 350 K) set to "within range" otherwise set to "out of range" end if |
| Band M13 Brightness Temperature Quality | viirs_mod_SDR_bt_type | if (180 K < $BT_{M13}$ < 350 K) set to "within range" otherwise set to "out of range" end if |
| Band M15 Brightness Temperature Quality | viirs_mod_SDR_bt_type | if (180 K < $BT_{M15}$ < 350 K) set to "within range" otherwise set to "out of range" end if |


Check the JPSS MIS Server at https://jpssmis.gsfc.nasa.gov/frontmenu_dsp.cfm to verify that this is the correct version prior to use.

| LST Flag | Input Source | Flag Setting |
|---|---|---|
| Band M16 Brightness Temperature Quality | viirs_mod_SDR_bt_type | if (180 K < $BT_{M16}$ < 350 K) set to “within range” otherwise set to “out of range” end if |
| AOT Condition | VIIRS_AOT_IP | if (AOT > 1.0) set to “out of range” otherwise set to “within range” end if |
| Day/Night | VIIRS_CLOUD_MASK_IP_TYPE | if (0 deg <= Solar Zenith Angle <= 85 deg) set to “Day” otherwise set to “Night” end if |
| Terminator | VIIRS_CLOUD_MASK_IP_TYPE | if (85 deg < Solar Zenith Angle <= 100 deg) set to “Inside Terminator” otherwise set to “Beyond Terminator” end if |
| Horizontal Reporting Interval | VIIRS_CLOUD_MASK_IP_TYPE | if (0 deg <= Sensor Zenith Angle <= 50.3 deg) set to “within range” otherwise set to “out of range” end if |
| Sun Glint | VIIRS_CLOUD_MASK_IP_TYPE | if (VCM Glint Flag == “No Glint”) set to “None” otherwise set to “Present” end if |
| Active Fire | VIIRS Surface Type EDR | LST Active Fire Flag = SurfaceType EDR Active Fire Flag |
| Cloud Confidence Indicator | VIIRS_CLOUD_MASK_IP_TYPE | LST Cloud Confidence Indicator = VCM Cloud Confidence Indicator |
| Land/Water | VIIRS_CLOUD_MASK_IP_TYPE | LST LandWater = VCM LandWater flag |
| Exclusion – Thin Cirrus | VIIRS_CLOUD_MASK_IP_TYPE | LST Thin Cirrus = VCM Thin Cirrus flag |
| SurfaceType | VIIRS Surface Type EDR | LST SurfaceType = SurfaceType EDR Surface Type (See note above in Section 2.1.2.3) |
| Algorithm | Logical combination of LST Flags | if ($BT_{M12}$ is “within range”) and ($BT_{M13}$ is “within range”) and (Terminator is “Beyond Terminator”) and (Glint is “No Glint”) and (Active Fire is “No Active Fire”) and (algmode is not set ot “Split”) set to “Dual” otherwise set to “Split” end if |
| Degraded – Sensor Zenith Angle > 40 | viirs_mod_SDR_bt_type | If (Sensor Zenith Angle > 40) set to LST_ZSEN_DEGRAD |
| Quality | Logical combination of LST Flags | See Table 9 |

**Table 9. LST QF/Quality Bit Field Logic Table (Retrieval Cases Only)**

| No Land | M15 & M16 Available | LST >= 0 | Degraded – Sensor Zenith Angle > 40 | Active Fire | Horizontal Reporting Interval | AOT Range | Thin Cirrus | Cloud Confidence Indicator | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Confident Clear | Probably Clear | Probably Cloudy |
| F | T | T | x | x | x | x | yes | Low | Low | Low |
| F | T | T | x | x | x | out | x | Low | Low | Low |
| F | T | T | x | x | out | x | x | Low | Low | Low |
| F | T | T | x | fire | x | x | x | Low | Low | Low |
| F | T | T | out | no | in | in | no | Medium | Medium | Low |
| F | T | T | in | no | in | in | no | High | Medium | Low |
| T | F | F | x | x | x | x | x | No Retrieval | No Retrieval | No Retrieval |

LST >= 0: T = True; F = False
Degraded – Sensor Zenith > 40: out = Outside Range, in = Within Range
Active Fire: no = no active fire; fire = active fire
Horizontal Reporting Interval: out = Outside Range, in = Within Range



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AOT Range: out = Outside Range, in = Within Range
Thin Cirrus: yes = Thin Cirrus, no = No Thin Cirrus
x = “Indifferent”

Refer to Table 8 to obtain the algorithm determination logic.

#### 2.1.2.4 LST LUT Coefficient Selection

A unique set of regression coefficients is derived offline for each land type. Each LST core equation (Table 10) uses a different set of coefficients for a given land STYP and day/night condition. Access to the coefficients is achieved by setting the values of the indices based on the given pixel viewing conditions and indicating the algorithm approach to be used. Once indices are specified, coefficients are retrieved for the desired LST algorithm by indexing on the “term” index. Currently, the “regime” index is set to “0” and has only one value. It is a placeholder for possible future improvement by further stratification of atmospheric conditions or geolocations. For the dual split-window algorithm, there are nine coefficients. For the split-window fallback algorithm, there are five coefficients. For the latter, four additional zero-valued coefficients are present as “fillers” in the LUT file.

Example:

> LUTCoeffs[n][1][14][0][0], where n is indexed from 0 to 8, corresponds to the coefficients $a_0$ to $a_8$ of the dual split algorithm under daytime viewing conditions with no solar glint or active fire and with a pixel viewing surface type 14.

**Table 10. LST Core Equations**

| **VIIRS single split-window LST algorithm (Operational Baseline Algorithm)** |
|---|
| Daytime: |
| $LST = a_0 + a_1 T_{M15} + a_2 (T_{M15} - T_{M16}) + a_3 (\sec\theta - 1) + a_4 (T_{M15} - T_{M16})^2$ |
| Nighttime: |
| $LST = b_0 + b_1 T_{M15} + b_2 (T_{M15} - T_{M16}) + b_3 (\sec\theta - 1) + b_4 (T_{M15} - T_{M16})^2$ |
| **VIIRS dual split-window LST algorithm (Optional Algorithm)** |
| Daytime: |
| $LST = a_0 + a_1 T_{M15} + a_2 (T_{M15} - T_{M16}) + a_3 (\sec\theta - 1) + a_4 T_{M12} + a_5 T_{M13} + a_6 T_{M12} \cos\varphi + a_7 T_{M13} \cos\varphi + a_8 (T_{M15} - T_{M16})^2$ |
| Nighttime: |
| $LST = b_0 + b_1 T_{M15} + b_2 (T_{M15} - T_{M16}) + b_3 (\sec\theta - 1) + b_4 T_{M12} + b_5 T_{M13} + b_6 T_{M12}{}^2 + b_7 T_{M13}{}^2 + b_8 (T_{M15} - T_{M16})^2$ |
| where,<br>LST is the retrieved land surface temperature,<br>$a_n$ and $b_n$ are coefficients retrieved from the LST LUT and are dependent on surface type and day/night conditions,<br>$\theta$ is the sensor zenith angle,<br>$\varphi$ is the solar zenith angle,<br>$T_\lambda$ is the brightness temperature at $\lambda$ = VIIRS Band M15, M16, M12 or M13.<br><br>The equations above correspond to the LST ATBD, 474-00051, Section 3.3.2, Equations (14), (15) and (16) with minor modifications (i.e., in order to simplify the software; coefficients for the daytime and nighttime equations for the baseline algorithm are equal). |

### 2.1.3 Graceful Degradation

#### 2.1.3.1 Graceful Degradation Inputs

There are two cases where input graceful degradation is indicated in the Land Surface Temperature EDR.

1. The primary input denoted in the algorithm configuration guide cannot be successfully retrieved but an alternate input can be retrieved.
2. An input retrieved for the algorithm had its N_Graceful_Degradation metadata field set to YES (propagation).

Table 11 details the instances of these two cases for LST. Note that the shaded cells indicate that the graceful degradation was done upstream at product production.



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**Table 11. LST Graceful Degradation**

| Input Data Description | Satellite | Baseline Data Source | Primary Backup Data Source | Secondary Backup Data Source | Tertiary Backup Data Source | Graceful Degradation Done Upstream |
|---|---|---|---|---|---|---|
| Surface Type EDR | NPP, PM1, TR1 | VIIRS_LN_04.4.1 VIIRS | VIIRS_GD_08.4.3 VIIRS Quarterly Surface Type IP | N/A | N/A | No |
| Aerosol Optical Thickness | NPP, PM1, TR1 | VIIRS_GD_15.4.1 VIIRS AOT IP | VIIRS_GD_25.4.1 NAAPS | VIIRS_GD_15.4.1 Climatology | N/A | Yes, backup only. |

#### 2.1.3.2 Graceful Degradation Processing

None.

#### 2.1.3.3 Graceful Degradation Outputs

None.

### 2.1.4 Exception Handling

When LST cannot be retrieved due to conditions such as invalid SDR data, cloud-contaminated pixel, invalid STYP, or sea-water pixel classification from the VCM IP Land/Water Flag, LST pixel values are set to NA_FLOAT32_FILL.

In addition to this, code is added to check the bounds of the input into the LST EDR. Table 3 contains all inputs for LST EDR and the valid ranges of these inputs. Table 7 contains input values to LST that are configurable and can be changed without having to recompile. The “assigned values” field lists the current value of this input. These inputs are put into a global file.

Very few operations in the algorithm (beyond address references) have the potential to cause exceptions. There are no divide operations in any routine that could be a division by zero.

### 2.1.5 Data Quality Monitoring

Each algorithm uses specific criteria contained in a Data Quality Threshold Table (DQTT) to determine when a Data Quality Notification (DQN) is produced. The DQTT contains the threshold used to trigger the DQN as well as the text contained in the DQN. If a threshold is met, the algorithm stores a DQN in DMS indicating the test(s) that failed and the value of the DQN attribute. For more algorithm specific detail refer to the CDFCB-X, 474-00001.

### 2.1.6 Computational Precision Requirements

The Land Surface Temperature is a scaled value ranging from 0 to 65527. The loss of precision from replacing this value (resolution of the scaled output versus the required accuracy and precision of the LST EDR) with a scaled 16-bit integer is acceptable. After calculation, the value is scaled by 65527 / 166.8. The loss of precision by scaling is approximately 0.00255 K.

### 2.1.7 Algorithm Support Considerations

INF and DMS must be running before the Land Surface Temperature algorithm is executed.

### 2.1.8 Assumptions and Limitations

#### 2.1.8.1 Assumptions

The LST retrieval algorithm assumes VIIRS 750 M SDR, VIIRS AOT IP, VCM IP, and VIIRS STYP EDR are available before processing.

#### 2.1.8.2 Limitations

The LST EDR is retrieved under clear condition with known STYP classification and valid brightness temperatures from at least the VIIRS M15 and M16 bands, and with AOT<1 to have a retrieved pixel of high quality.  A pixel of low quality is retrieved if AOT is out of the acceptable bounds.

Precipitable Water (PW), atmospheric transmittance and surface emissivity corrections discussed in Section 3.3.4 of the ATBD, 474-00051, are not implemented.



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# 3.0 GLOSSARY/ACRONYM LIST

## 3.1 Glossary

Table 12 contains terms most applicable for this OAD.

**Table 12. Glossary**

| Term | Description |
|---|---|
| Algorithm | A formula or set of steps for solving a particular problem. Algorithms can be expressed in any language, from natural languages like English to mathematical expressions to programming languages like FORTRAN. On NPOESS, an algorithm consists of:<br>A theoretical description (i.e., science/mathematical basis)<br>A computer implementation description (i.e., method of solution)<br>A computer implementation (i.e., code) |
| Algorithm Configuration Control Board (ACCB) | Interdisciplinary team of scientific and engineering personnel responsible for the approval and disposition of algorithm acceptance, verification, development and testing transitions. Chaired by the Algorithm Implementation Process Lead, members include representatives from IWPTB, Systems Engineering & Integration IPT, System Test IPT, and IDPS IPT. |
| Algorithm Verification | Science-grade software delivered by an algorithm provider is verified for compliance with data quality and timeliness requirements by Algorithm Team science personnel. This activity is nominally performed at the IWPTB facility. Delivered code is executed on compatible IWPTB computing platforms. Minor hosting modifications may be made to allow code execution. Optionally, verification may be performed at the Algorithm Provider's facility if warranted due to technical, schedule or cost considerations. |
| Ancillary Data | Any data which is not produced by the NPOESS System, but which is acquired from external providers and used by the NPOESS system in the production of NPOESS data products. |
| Auxiliary Data | Auxiliary Data is defined as data, other than data included in the sensor application packets, which is produced internally by the NPOESS system, and used to produce the NPOESS deliverable data products. |
| EDR Algorithm | Scientific description and corresponding software and test data necessary to produce one or more environmental data records. The scientific computational basis for the production of each data record is described in an ATBD. At a minimum, implemented software is science-grade and includes test data demonstrating data quality compliance. |
| Environmental Data Record (EDR) | [IORD Definition]<br>Data record produced when an algorithm is used to convert Raw Data Records (RDRs) to geophysical parameters (including ancillary parameters, e.g., cloud clear radiation, etc.).<br>[Supplementary Definition]<br>An Environmental Data Record (EDR) represents the state of the environment, and the related information needed to access and understand the record. Specifically, it is a set of related data items that describe one or more related estimated environmental parameters over a limited time-space range. The parameters are located by time and Earth coordinates. EDRs may have been resampled if they are created from multiple data sources with different sampling patterns. An EDR is created from one or more NPOESS SDRs or EDRs, plus ancillary environmental data provided by others. EDR metadata contains references to its processing history, spatial and temporal coverage, and quality. |
| Model Validation | The process of determining the degree to which a model is an accurate representation of the real-world from the perspective of the intended uses of the model. [Ref.: DoDD 5000.59-DoD Modeling and Simulation Management] |
| Model Verification | The process of determining that a model implementation accurately represents the developer's conceptual description and specifications. [Ref.: DoDD 5000.59-DoD Modeling and Simulation Management] |
| Operational Code | Verified science-grade software, delivered by an algorithm provider and verified by IWPTB, is developed into operational-grade code by the IDPS IPT. |
| Operational-Grade Software | Code that produces data records compliant with the System Specification requirements for data quality and IDPS timeliness and operational infrastructure. The software is modular relative to the IDPS infrastructure and compliant with IDPS application programming interfaces (APIs) as specified for TDR/SDR or EDR code. |



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| Term | Description |
|---|---|
| Raw Data Record (RDR) | [IORD Definition]<br>Full resolution digital sensor data, time referenced and earth located, with absolute radiometric and geometric calibration coefficients appended, but not applied, to the data. Aggregates (sums or weighted averages) of detector samples are considered to be full resolution data if the aggregation is normally performed to meet resolution and other requirements. Sensor data shall be unprocessed with the following exceptions: time delay and integration (TDI), detector array non-uniformity correction (i.e., offset and responsivity equalization), and data compression are allowed. Lossy data compression is allowed only if the total measurement error is dominated by error sources other than the data compression algorithm. All calibration data will be retained and communicated to the ground without lossy compression.<br>[Supplementary Definition]<br>A Raw Data Record (RDR) is a logical grouping of raw data output by a sensor, and related information needed to process the record into an SDR or TDR. Specifically, it is a set of unmodified raw data (mission and housekeeping) produced by a sensor suite, one sensor, or a reasonable subset of a sensor (e.g., channel or channel group), over a specified, limited time range. Along with the sensor data, the RDR includes auxiliary data from other portions of NPOESS (space or ground) needed to recreate the sensor measurement, to correct the measurement for known distortions, and to locate the measurement in time and space, through subsequent processing. Metadata is associated with the sensor and auxiliary data to permit its effective use. |
| Retrieval Algorithm | A science-based algorithm used to 'retrieve' a set of environmental/geophysical parameters (EDR) from calibrated and geolocated sensor data (SDR). Synonym for EDR processing. |
| Science Algorithm | The theoretical description and a corresponding software implementation needed to produce an NPP/NPOESS data product (TDR, SDR or EDR). The former is described in an ATBD. The latter is typically developed for a research setting and characterized as "science-grade". |
| Science Algorithm Provider | Organization responsible for development and/or delivery of TDR/SDR or EDR algorithms associated with a given sensor. |
| Science-Grade Software | Code that produces data records in accordance with the science algorithm data quality requirements. This code, typically, has no software requirements for implementation language, targeted operating system, modularity, input and output data format or any other design discipline or assumed infrastructure. |
| SDR/TDR Algorithm | Scientific description and corresponding software and test data necessary to produce a Temperature Data Record and/or Sensor Data Record given a sensor's Raw Data Record. The scientific computational basis for the production of each data record is described in an Algorithm Theoretical Basis Document (ATBD). At a minimum, implemented software is science-grade and includes test data demonstrating data quality compliance. |
| Sensor Data Record (SDR) | [IORD Definition]<br>Data record produced when an algorithm is used to convert Raw Data Records (RDRs) to calibrated brightness temperatures with associated ephemeris data. The existence of the SDRs provides reversible data tracking back from the EDRs to the Raw data.<br>[Supplementary Definition]<br>A Sensor Data Record (SDR) is the recreated input to a sensor, and the related information needed to access and understand the record. Specifically, it is a set of incident flux estimates made by a sensor, over a limited time interval, with annotations that permit its effective use. The environmental flux estimates at the sensor aperture are corrected for sensor effects. The estimates are reported in physically meaningful units, usually in terms of an angular or spatial and temporal distribution at the sensor location, as a function of spectrum, polarization, or delay, and always at full resolution. When meaningful, the flux is also associated with the point on the Earth geoid from which it apparently originated. Also, when meaningful, the sensor flux is converted to an equivalent top-of-atmosphere (TOA) brightness. The associated metadata includes a record of the processing and sources from which the SDR was created, and other information needed to understand the data. |
| Temperature Data Record (TDR) | [IORD Definition]<br>Temperature Data Records (TDRs) are geolocated, antenna temperatures with all relevant calibration data counts and ephemeris data to revert from T-sub-a into counts.<br>[Supplementary Definition]<br>A Temperature Data Record (TDR) is the brightness temperature value measured by a microwave sensor, and the related information needed to access and understand the |



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| Term | Description |
|---|---|
| | record. Specifically, it is a set of the corrected radiometric measurements made by an imaging microwave sensor, over a limited time range, with annotation that permits its effective use. A TDR is a partially-processed variant of an SDR. Instead of reporting the estimated microwave flux from a specified direction, it reports the observed antenna brightness temperature in that direction. |


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## 3.2 Acronyms

Table 13 contains acronyms most applicable for this OAD.

**Table 13. Acronyms**

| Term | Expansion |
|---|---|
| AM&S | Algorithms, Models & Simulations |
| API | Application Programming Interfaces |
| ARP | Application Related Product |
| CDFCB-X | Common Data Format Control Book - External |
| DMS | Data Management Subsystem |
| DPIS ICD | Data Processor Inter-subsystem Interface Control Document |
| DQTT | Data Quality Test Table |
| INF | Infrastructure |
| ING | Ingest |
| IP | Intermediate Product |
| LST | Land Surface Temperature |
| LUT | Look-Up Table |
| MDFCB | Mission Data Format Control Book |
| PW | Precipitable Water |
| QF | Quality Flag |
| SDR | Sensor Data Records |
| SI | Software Item or International System of Units |
| SST | Sea Surface Temperature |
| STYP | Surface Type |
| TBD | To Be Determined |
| TBR | To Be Resolved |
| VCM | VIIRS Cloud Mask |

## 4.0 OPEN ISSUES

**Table 14. TBXs**

| TBX ID | Title/Description | Resolution Date |
|---|---|---|
| None | | |
| | | |
| | | |



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