MODIS Land Surface Temperature Products

Users' Guide

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ALERT ---

This document is a living document that describes the MODIS Land Surface Temperature (LST) products. It is revised as progress is made in the development and assessment of the LST products. Described is the current state of the MODIS LST products. The purpose of the document is to give the potential user of LST products an understanding of the MODIS LST products and the data in those products.

The MODIS LST products MOD11_L2, MOD11A1, MOD11A2, and MOD11B1 have been validated at stage 1 with in situ measurements in 28 clear-sky cases including 19 cases over land sites in the temperature range of 263-322K and the column water vapor range of 0.4-4cm. More validation activities are under way.

The MOD11C series MODIS LST products at 0.05 degree latitude/longitude climate model grids (CMG) derived from the MOD11B1 product have been released in June 2003.

The descriptions of V4 Terra MODIS LST products (named starting with MOD11) in this users' guide also apply to the V3 and V4 Aqua MODIS LST products (named starting with MYD11) which are generated with the same V4 LST code.

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1. *Introduction*

The MODIS LST products are created as a sequence of products beginning with a swath (scene) and progressing, through spatial and temporal transformations, to daily and eight-day global gridded products. The algorithms and data content of these LST products are briefly described in this guide with the purpose of providing a user with sufficient information about the content and structure of the data files to enable the user to access and use the data. Overviews of the file format and sequence of MODIS LST products are given first. Descriptions of each algorithm and product content are given in following sections. Publications and documents related to the MODIS LST products are listed in the last two sections.

1.1. File Format of LST Products

The MODIS LST products are archived in Hierarchical Data Format - Earth Observing System (HDF-EOS) format files. HDF, developed by the NSCA, is the standard archive format for EOS Data Information System (EOSDIS) products. The LST product files contain global attributes (metadata) and scientific data sets (SDSs) (arrays) with local attributes. Unique in HDF-EOS data files is the use of HDF features to create point, swath, and grid structures to support geolocation of data. These structures (Vgroups and Vdata) provide geolocation relationships between data in an SDS and geographic coordinates (latitude and longitude or map projections) to support mapping the data. Attributes (metadata), global and local, provide various information about the data. Users unfamiliar with HDF and HDF-EOS formats may wish to consult Web sites listed in the Related Web Sites section for more information.

LST data product files contain three EOS Data Information System (EOSDIS) Core System (ECS) global attributes, which are also referred to as metadata by ECS. These ECS global attributes (*CoreMetadata.0*, *ArchiveMetadata.0* and *StructMetadata.0)* contain information relevant to production, archiving, user services, geolocation and analysis of data. The ECS global attributes are written in parameter value language (PVL) and are stored as a character string. Metadata and values are stored as objects within the PVL string. Results of the LST algorithms are stored as SDSs with local attributes. Local attributes include summary statistics and other information about the data in an SDS or a key to data values. Detailed descriptions of each LST product are given in following sections.

Products may also contain product specific attributes (PSAs) defined by the product developers as part of the ECS *CoreMetadata.0* attribute. Geolocation and gridding relationships between HDF-EOS point, swath, and grid structures and the data are contained in the ECS global attribute, *StructuralMetadata.0*.

A separate file containing metadata will accompany data products ordered from a DAAC. That metadata file will have a .met extension and is written in PVL. The .met file

contains some of the same metadata as in the product file but also has other information regarding archiving and user support services as well as some post production quality assurance (QA) information relevant to the product file ordered. The post production QA metadata may or may not be present depending on whether or not the data file has been investigated. The .met file should be examined to determine if post production QA has been applied to the product file. (The Quality Assurance sections of this guide provide information on post production QA.)

The data products were generated in the science data production system using the HDF-EOS toolkit, Science Data Processing (SDP) Toolkit, HDF API and the C programming language. Various software packages, commercial and public domain, are capable of accessing the HDF-EOS files.

1.2. Sequence of LST Products

LST data products are produced as a series of seven products. The sequence begins as a swath (scene) at a nominal pixel spatial resolution of 1km at nadir and a nominal swath coverage of 2030 or 2040 lines (along track, about five minutes of MODIS scans) by 1354 pixels per line. A summarized listing of the sequence of products is given in Table 1. Products in EOSDIS are labeled as Earth Science Data Type (ESDT), the ESDT label "shortname" is used to identify the LST data products. Except for the initial daily LST products, MOD11_L2, MOD11A1, and MOD11B1, each LST product in the sequence is built from the previous LST products. These LST products are identified, in part, by product levels in EOSDIS which indicate what spatial and temporal processing has been applied to the data.

Data product levels briefly described: Level 1B (L1B) is a swath (scene) of MODIS data geolocated to latitude and longitude centers of 1 km resolution pixels. A level 2 (L2) product is a geophysical product that remains in latitude and longitude orientation; it has not been temporally or spatially manipulated. A level 3 (L3) product is a geophysical product that has been temporally and or spatially manipulated, and is usually in a gridded map projection format referred to as tiles. Each tile is a piece, e.g., about 1113km by 1113km in 1200 rows by 1200 columns, of a map projection.

Brief descriptions of the LST data products are given here to give perspective to the sequence. Expanded descriptions of the LST products are given in following sections.

The first product, MOD11_L2, is a LST product at 1km spatial resolution for a swath. This product is the result of the generalized split-window LST algorithm (Wan and Dozier, 1996). Geolocation data (latitude and longitude) at 5 km resolution is also stored in the product. The second product, MOD11A1, is a tile of daily LST product at 1km spatial resolution. It is generated by mapping the pixels from the MOD11_L2 products for a day to the Earth locations on the integerized sinusoidal or sinusoidal projection. The third product, MOD11B1, is a tile of daily LST and emissivities at 5km spatial resolution. It is generated by the day/night LST algorithm (Wan and Li, 1997). The fourth product, MOD11A2, is an eight-day LST product by averaging from two to eight days of the

MOD11A1 product. The fifth product, MOD11C1, is a daily global LST product in a geographic projection. It is created by assembling the MOD11B1 daily tiles together and resampling the 5km cell observations to the 0.05° spatial resolution of the Climate Modeling Grid (CMG) cells. The sixth product, MOD11C2, is an eight-day composite of LST at the same resolution as MOD11C1. The seventh product, MOD11C3, is a monthly composite of LST at the same resolution as MOD11C2.

The day/night LST algorithm needs a pair of daytime and nighttime L1B data in seven TIR bands, atmospheric temperature and water vapor in the MODIS atmospheric product MOD07_L2. BRDF parameters in the MODIS BRDF product MOD43B1C are also used in the V4 processing. The initial MOD11B1 product was released in July 2001. The V4 MOD11A1, MOD11A2, and MOD11B1 products generated from reprocessing of MODIS data since late February 2000 and forward processing of MODIS data since early 2003 were released in early 2003. The MODIS CMG LST products (MOD11C1-3) have been released recently (June 2003).

Table 1. Summary of the MODIS LST data products.

Earth Science Data Type (ESDT)	Product Level	Nominal Data Array Dimensions	Spatial Resolution	Temporal Resolution	Map Projection
MOD11_L2	L2	2030 or 2040 lines by 1354 pixels per line	1km at nadir	swath (scene)	None. (lat,lon referenced)
MOD11A1	L3	1200 rows by 1200 columns	1km (actual 0.928km)	daily	Integerized Sinusoidal or Sinusoidal
MOD11B1	L3	240 rows by 240 columns	5km (actual 4.638km)	daily	Integerized Sinusoidal or Sinusoidal
MOD11A2	L3	1200 rows by 1200 columns	1km (actual 0.928km)	eight days	Integerized Sinusoidal or Sinusoidal
MOD11C1	L3	360° by 180° (global)	0.05° by 0.05°	daily	equal-angle geographic
MOD11C2	L3	360° by 180° (global)	0.05° by 0.05°	eight days	equal-angle geographic
MOD11C3	L3	360° by 180° (global)	0.05° by 0.05°	monthly	equal-angle geographic

2. MOD11_L2 LST Product

This product is generated using the MODIS sensor radiance data product (MOD021KM), the geolocation product (MOD03), the cloud mask product (MOD35_L2), the quarterly landcover (MOD12Q1), and snow product (MOD10_L2). The output file contains SDSs of LST, quality assurance (QA), error in LST, emissivities in bands 31 and 32, viewing zenith angle and time, latitude and longitude (each set of latitude and longitude for every 5 scan lines and 5 pixels), local attributes, and global attributes. This LST product is generated by the generalized split-window LST algorithm (Wan and Dozier, 1996). For complete global coverage a MOD11_L2 LST product would be generated for all swaths acquired in daytime and nighttime on the Earth including the polar regions.

The algorithm and data product contents for MOD11_L2 are described in the following sections.

2.1. Algorithm Description

A brief sketch of the LST algorithm for MOD11_L2 is described here for the purpose of aiding the user in understanding and interpreting the data product.

The LST retrieval in a MODIS swath is constrained to pixels that:

(1). have nominal Level 1B radiance data,
(2). are in clear-sky conditions at a 99% confidence defined in MOD35,
(3). are on land or inland water.

In the V4 LST processing, LST retrieval is made for lake and river pixels at clear-sky conditions with a 66% and higher confidence defined in cloud-mask MOD35 and for other land pixels in clear-sky at a 99% confidence, in order to improve the consistency between the spatial LST distributions over lakes and their surrounding lands.

Data inputs to the LST algorithm are listed in Table 2.

Clouds are masked with the MODIS Cloud Mask data product (MOD35_L2).

Masking of oceans is done with the 1 km resolution land/water mask, contained in the MODIS geolocation product (MOD03).

Table 2. MODIS data product inputs to the MODIS LST algorithm for the MOD11_L2 product.

ESDT	Long Name	Data Used
MOD021KM	MODIS Level 1B Calibrated and Geolocated Radiances	EV_1KM_Emissive for MODIS bands: 31 (11.03 µm) 32 (12.02 µm)
MOD03	MODIS Geolocation	Land/Water Mask

		Height Sensor Zenith Angles Solar Zenith Angles Latitude Longitude EV start time
MOD35_L2	MODIS Cloud Mask	Cloud_Mask Latitude (every 5 lines) Longitude (every 5 pixels)
MOD07_L2	MODIS Atmospheric Profile	Surface_Temperature Water_Vapor
MOD12Q1	Land Cover	Land_Cover_Type_1
MOD10_L2	MODIS Snow Cover	Snow Cover

Emissivities in bands 31 and 32 are estimated by the classification-based emissivity method (Snyder and Wan, 1998) according to land cover types in the pixel determined by the input data in quarterly Land Cover (MOD12Q1) and daily Snow Cover (MOD10_L2). In the first year of the MODIS LST production, the landcover product used in the LST algorithm is the IGBP type land cover product produced by the University of Maryland Landcover group based on AVHRR data in the early years. Since June 2001, the land-cover product generated from MODIS data is used in the MODIS LST processing. A large uncertainty may exist in such estimated emissivities in semi-arid and arid areas. So the quality of the MOD11_L2 product may be poor in these areas. Users are advised to use caution applying the MOD11_L2 LST data to project-applications, especially in semi-arid and arid areas.

Because band 22 is used in the 4-11 micron test to determine the cloudyness of a pixel in the MODIS cloudmask algorithm, the noisy fourth channel in band 22 produced quite a lot of (cloud) strips in the cloudmask product based on the old A-side MODIS data (prior to October 30, 2000). To avoid the strips caused by the noisy channels, the cloudmask in all fourth channels of the scan cubes (one scan cub contains ten channels in each band) is refined with the adjacent pixels in the third and fifth channels. If both the adjacent pixels in the third and fifth channels are clear-sky pixels at a 99% confidence (66% or higher for inland water pixels in V4), the pixel in the fourth channel will be treated as clear-sky pixel for the LST retrieval.

2.2. Scientific Data Sets (SDS)

The MODIS L2 LST product contains nine scientific data sets (SDSs): LST, QC, Error_LST, Emis_31, Emis_32, View_angle, View_time, Latitude, and Longitude. The first seven DSDs are for 1km pixels. The last two DSDs are coarse resolution (5 km) latitude and longitude data. Each set of them correspond to a center pixel of a 5 km by 5 km block of pixels in the LST SDS. A mapping relationship of geolocation data to the first seven DSDs is specified in the global attribute *StructMetadata.0*. The mapping relationship was created by the HDF-EOS SDPTK toolkit during production. Geolocation data is mapped to the first seven DSDs data with an offset = 2 and increment = 5. The first element (0,0) in the geolocation SDSs corresponds to element (2,2) in LST

SDS, then increments by 5 in the cross-track or along-track direction to map geolocation data to the LST SDS element. Details are shown in Table 3.

Table 3. The SDSs in the MOD11_L2 product.

SDS Name	Long Name	Number Type	Unit	Valid Range	Fill Value	scale factor	add offset
LST	Land-surface temperature	uint16	K	7500-65535	0	0.02	0.0
QC	Quality control for LST and emissivity	uint16	none	0-65535	0	NA	NA
Error_LST	Land-surface temperature error	uint8	K	1-255	0	0.04	0.
Emis_31	Band 31 emissivity	uint8	none	1-255	0	0.002	0.49
Emis_32	Band 32 emissivity	uint8	none	1-255	0	0.002	0.49
View_angle	zenith angle of MODIS viewing at the pixel	uint8	deg	0-180	0	0.5	0
View_time	Time* of Land-surface Temperature observation (* as local solar time)	uint8	hrs	0-240	0	0.1	0
Latitude	Latitude of every 5 scan lines and 5 pixels	float32	degree	-90.0 to 90.0	-999.9	NA	NA
Longitude	Longitude of every 5 scan lines and 5 pixels	float32	degree	-180.0 to 180.0	-999.9	NA	NA

Note that the Error_LST value is only an estimated value. It is quite conservative in real clear-sky conditions. However, the effect of cloud contaminations is not considered in the error estimation.

2.3. Local Attributes

Archived with the "LST" SDS are local attributes including the coefficients of the calibration which converts the SDS value to real LST value in K. HDF predefined local attributes (Table 4) describe characteristics of the data.

Table 4. HDF-predefined local attributes for SDS LST in the MOD11_L2 product.

Attribute Name	Reserved Label(s)	Definition	Sample Value
Label	long_name	Long Name of the SDS	Land-surface Temperature
Unit	units	SI units of the data, if any	K
Format	Number Type	How the data are stored	uint16 (16-bit unsigned integer)
Range	valid_range	Max and min values within a selected data range	7500-65535 *
Fill Value	_FillValue	Data used to fill gaps in the swath	0

	scale_factor	scaling factor	0.02
	add_offset	add offset	0.
Calibration	scale_factor_err	scaling factor error	0.
	add_offset_err	add offset error	0.
	calibrated_nt	calibrated nt	0.

* The number 65535 in uint16 may be shown as -1s in 16-bit integer by some software toolkits,for example, by ncdump in the HDF toolkit.

The effective calibration formula for the "LST" SDS is

LST = the SDS data in uint16 * 0.02, giving a value in the range of 150-1310.7K.

2.4. Global Attributes

There are three global ECS attributes, i.e., *CoreMetadata.0*, *ArchiveMetadata.0*, and *StructMetadata.0,* in the MOD11_L2 data product. Contents of these global attributes were determined and written during generation of the product and are used in archiving and populating the EOSDIS database to support user services. They are stored as very long character strings in parameter value language (PVL) format. Descriptions of the global attributes are given here to assist the user in understanding them.

CoreMetadata.0 is the global attribute in which information compiled about the product during product generation is archived and is used to populate the EOSDIS database to support user services. The content of the global attributes with sample values and comment of definition are listed in Table 5, Table 6, and Table 7, respectively. The user wanting detailed explanations of the global attributes and related information should query the EOSDIS related web sites.

Table 5. Listing of objects in the global attribute *CoreMetadata.0* in MOD11_L2.

Object Name	Sample Value	Comment
ShortName	"MOD11_L2"	ESDT name of product
VersionID	1	ECS Version
ReprocessingActual	"processed once"	
ReprocessingPlanned	"further update is anticipated"	Expect that products will be reprocessed one or more times.
LocalGranuleID	"MOD11_L2.A2000207.1915.002.2000243053331.hdf"	
DayNightFlag	"Day"	Day , Night or Both.
ProductionDateTime	"2000-08-30T05:33:31.000Z"	
LocalVersionID	"SCF V2.2.16"	Version of algorithm delivered from the SCF.
PGEVersion	"2.2.16"	Version of

		production generation executable.
InputPointer	"MOD03.A2000207.1915.002.2000212171250.hdf","..."	Location of input files in the production system.
RangeBeginningDate	"2000-07-25"	Beginning and ending times of the first and last scan line in the swath.
RangeBeginningTime	"19:15:00.000000"	
RangeEndingDate	"2000-07-25"	
RangeEndingTime	"19:20:00.000000"	
ExclusionGRingFlag	"N"	Geographic bounds of swath coverage.
GRingPointLatitude	[50.334011, 45.870819, 28.863239, 32.337044]	
GRingPointLongitude	[-134.358658, -103.376228, -112.166939, -136.159561]	
GRingPointSequenceNo	[1,2,3,4]	
OrbitNumber	3210	
EquatorCrossingLongitude	-131.022286	
EquatorCrossingDate	"2000-07-25"	
EquatorCrossingTime	"19:28:37.410935"	
ParameterName	"MODIS LST"	
AutomaticQualityFlag	"Passed"	Result of automated checks during the run of the algorithm that screen for significant amounts of anomalous data.
AutomaticQuality	"Passed if algorithm ran within bounds of execution constraints. Suspect if bounds of execution constraints violated. Failed if PGE failed."	Explanation of result of automated QA checks made during execution.
OperationalQualityFlag	"Passed"	Set by production system.
OperationalQualityFlagExplanation	"Nominal Production"	Explanation of Operational Flag
ScienceQualityFlag	"Suspect"	Set by LST investigator after post-production investigation
SciencelQualityFlagExplanation	"Early product assessment is on going. Users are advised to use caution applying these data to project-applications, especially in semi-arid and arid areas. Input product are still being refined."	Explanation of Science Flag
QAPercentMissingData	0 (note that the value is incorrect in MOD11_L2 files generated by earlier than PGEVERSION 2.2.14)	0-100
QAPercentCloudCover	48 (for all pixels not VeryHighConfidentClear	0-100

	in MOD35_L2)	
AncillaryInputPointer	"MOD03.A2000207.1915.002.2000212171250.hdf"	Location of geolocation input product in production system.
AncillaryInputType	"Geolocation"	Type of ancillary data referenced by pointer.
AssociatedSensorShortName	"CCD"	
AssociatedPlatformShortName	"AM-1"	
AssociatedInstrumentShortName	"MODIS"	
Product Specific Attributes (PSA)		
QAPercentGoodQuality	34	Summary quality assurance statistic for data product. Range is from 0-100.
QAPercentOtherQuality	7	
QAPercentNotProducedCloud	12	
QAPercentNotProducedOther	47	
GranuleNumber	233	Unique granule identifier
QAFractionGoodQuality	0.3440894	Summary fraction of the LST product. Range is from 0.0 to 1.0.
QAFractionOtherQuality	0.0742003	
QAFractionNotProducedCloud	0.1152801	
QAFractionNotProducedOther	0.4664303	

The four QAFraction PSAs are specially useful to granules in ocean regions where only a small number of island pixels exist. Because the total number of land and coastal pixels is highly variable in granules covering both land and ocean, the values of QAPercent and QAFraction PSAs are calculated on the base of the total number of all pixels in a granule. Therefore, we can always calculate how many pixels with LST in good quality and other quality from these PSA values, even for island pixels.

The ECS global attribute *ArchiveMetadata.0* contains information relevant to production of the data product. It also contains an alternate bounding of geographic coverage of the swath. These data may be useful in determining what version of the algorithm was used to generate the product. Contents are described in Table 6.

Table 6. Listing of objects in the global attribute *ArchiveMetadata.0* in MOD11_L2.

Object Name	**Typical Value**	**Comment**
EastBoundingCoordinate	-103.376228	Extent of swath coverage, in latitude and longitude.
WestBoundingCoordinate	-136.159563	
NorthBoundingCoordinate	50.334012	
SouthBoundingCoordinate	28.863239	

AlgorithmPackageAcceptanceDate	"1997-11-01"	Algorithm Descriptors
AlgorithmPackageMaturityCode	"pre-launch"	
AlgorithmPackageName	"MOD_PR11_V2"	
AlgorithmPackageVersion	"Version 2"	
InstrumentName	"Moderate-Resolution Imaging SpectroRadiometer"	
AssociatedPlatformShortName	"AM-1"	
ProcessingDateTime	"2000-08-30T05:33:31.000Z"	
LongName	"MODIS/Terra Land Surface Temperature/Emissivity 5-Min L2 Swath 1km"	
Processing Center	"GSFC"	
SPSOParameters	"2484 and 3323"	
LocalInputGranuleID	"MOD021KM.A2000207.1915..."	input L1B HDF file.

The *StructMetadata.0* global attribute is used by the HDF-EOS toolkit to specify the mapping relationships between the geolocation data and the LST data (SDSs). Mapping relationships are unique in HDF-EOS and are stored in the product using HDF structures. Description of the mapping relationships is not given here. Use of HDF-EOS toolkit, other EOSDIS supplied toolkits, or other software packages may be used to geolocate the data.

Table 7. Listing of objects in the global attribute *StructMetadata.0* in MOD11_L2.

Object	Definition
DIMENSION_1	10*nscans (along_swath_lines_1km)
DIMENSION_2	Max_EV_frames (Cross_swath_pixels_1km)
DIMENSION_3	2*nscans (Coarse_swath_lines_5km)
DIMENSION_4	Max_EV_frames/5 (Coarse_swath_pixels_5km)
DIMENSIONMAP_1	GeoDimension=2*nscans DataDimension=10*nscans Offset=2 Increment=5
DIMENSIONMAP_2	GeoDimension=Max_EV_frames/5 DataDimension=Max_EV_frames Offset=2 Increment=5
GEOFIELD_1	GeoFieldName=Latitude
GEOFIELD_2	GeoFieldName=Longitude
DATAFIELD_1	DataFieldName=LST

DATAFIELD_2	DataFieldName=QC
DATAFIELD_3	DataFieldName=Error_LST
DATAFIELD_4	DataFieldName=Emis_31
DATAFIELD_5	DataFieldName=Emis_32
DATAFIELD_6	DataFieldName=View_angle
DATAFIELD_7	DataFieldName=View_time
DATAFIELD_8	DataFieldName=Latitude
DATAFIELD_9	DataFieldName=Longitude

2.5. Quality Assurance

Indicators of quality are given in metadata objects in the *CoreMetadata.0* global attribute QA and in a quality control (QC) SDS, generated during production, or in post-product scientific and quality checks of the data product. QA metadata objects in the *CoreMetadata.0* global attribute are the AutomaticQualityFlag and the ScienceQualityFlag and their corresponding explanations. The AutomaticQualityFlag is set according to rules based on data conditions encountered during a run of the LST algorithm. Setting of this QA flag is fully automated. The rules used to set it are liberal; nearly all of the data or intermediate calculations would have to be anomalous for it to be set to "Failed". Typically, it will be set to "Passed" or "Suspect". "Suspect" means that some bounds of execution constraints are violated and that further analysis should be done to determine the source. The ScienceQualityFlag is set post production either after an automated QA program is run on the data product or after the data product is inspected by a qualified LST investigator. Content and explanation of this flag are dynamic so it should always be examined if present. A sampling of products will be inspected. Sampling may be random, in support of field campaigns, or event driven.

The QC SDS in the data product provides additional information on algorithm results for each pixel. The QC SDS unsigned 16-bit data are stored as bit flags in the SDS. This QC information can be extracted by reading the bits in the 16-bit unsigned integer. The purpose of the QC SDS is to give the user information on algorithm results for each pixel that can be viewed in a spatial context. The QC information tells if algorithm results were nominal, abnormal, or if other defined conditions were encountered for a pixel. The QC information should be used to help determine the usefulness of the LST data for a user's needs. The bit flags in the QC SDS are listed in Table 8.

Table 8. Bit flags defined in the QC SDS in the MOD11_L2 product. Note that bit 0 is the least significant bit.

bits	Long Name	Key
1 & 0	Mandatory QA flags	00=Pixel produced, good quality, not necessary to examine more detailed QA 01=Pixel produced, unreliable or unquantifiable quality, recommend examination of more detailed QA 10=Pixel not produced due to cloud effects 11=Pixel not produced primarily due to reasons other than cloud (such as ocean pixel, poor input data)
3 & 2	Data quality flag	00=good 01=missing pixel 10=fairly calibrated 11=poorly calibrated, LST processing skipped
5 & 4	Cloud flag	00=cloud free pixel 01=pixel only with thin cirrus 10=fraction of sub-pixel clouds<= 2/16 11=TBD (in V3) or LST affected by nearby clouds (in V4)
7 & 6	LST model number	00=generalized split-window method 01=day/night method 10=high LST w/o atmospheric & emis corrections 11=cirrus effects corrected
9 & 8	LST quality flag	00=no multi-method comparison 01=multi-method comparison done 10=fair consistency 11=good consistency
11 & 10	Emissivity flag	00=inferred from land cover type 01=MODIS retrieved 10=TBD 11=default value used
13 & 12	Emis quality flag	00=emis quality not checked 01=emis quality checked with land cover type 10=emis quality checked with NDVI 11=emis view-angle dependence checked
15 & 14	Emis error flag	00=error in emis_31 emis_32 <= 0.01 01=error in emis_31 emis_32 <= 0.02 10=error in emis_31 emis_32 <= 0.04 11=error in emis_31 emis_32 > 0.04

It should be noted that fillvalue 0 listed for the SDS QC in Table 3 is valid for the bit flags only when a fillvalue 0 is present in the SDS LST pixels (so the 00-01 bits in the QC pxels have a value of 10 or 11). A value of 0 in the QC bit flags means good data quality, cloud free, or small error in emis_31 and emis_32, and etc, if a pixel has a valid LST value. We do not discriminate fillvalue 0 from valid value 0 for all bit flags in the QC in order to minimize the data volume. Users should read SDSs LST and QC at the same time in order to properly interpret their values in an easy way.

3. MOD11A1 Daily LST

The daily level 3 LST product at 1km spatial resolution is a tile of daily LST product gridded in the Integerized Sinusoidal projection (in V3) or the Sinusoidal projection (in V4). A tile contains 1200 by 1200 grids in 1200 rows and 1200 columns. The exact grid size at 1km spatial resolution is 0.928km by 0.928km.

3.1. Algorithm Description

The daily MOD11A1 LST product is constructed with the results in the MOD11_L2 products of a day through mapping the SDSs of all pixels in MOD11_L2 products onto grids in the integerized sinusoidal or sinusoidal projection and averaging the values in each grid.

As latitude increases beyond 30 degrees, the LST value at some grids in the MOD11A1 product may be the average value of LSTs retrieved from multiple MODIS observations in clear-sky conditions in day or night. If LST values from single clear-sky MODIS observations are required for all grids, the MOD11_L2 LST product and MODIS geolation product (MOD03) should be used instead.

3.2. Scientific Data Sets (SDS)

The SDSs in the MOD11A1 product include LST_Day_1km, QC_Day, Day_view_time, Day_view_angl, LST_Night_1km, QC_Night, Night_view_time, Night_view_angl, Emis_31, Emis_32, Clear_day_cov, Clear_night_cov, and Columns_per_Global_Grid_Row described in Table 9. Note that the scale factor and offset for Day_view_angle and Night_view_angle in V4 Level-3 MODIS LST products have been changed so that a negative sign of the viewing angle means MODIS viewing the grid from east. The view zenith angle itself is always a positive number, the zenith angle from nadir. The information of MODIS viewing the grid from east or west may be important in understanding the view angle effect in the temporal variations in LSTs, especially in rugged regions.

Table 9. The SDSs in the MOD11A1 product.

SDS Name	Long Name	Number Type	Unit	Valid Range	Fill Value	scale factor	add offset
LST_Day_1km	Daily daytime 1km grid Land-surface Temperature	uint16	K	7500-65535	0	0.02	0.0
QC_Day	Quality control for daytime LST and emissivity	uint8	none	0-255	0	NA	NA
Day_view_time	(local solar) Time of daytime Land-surface Temperature observation	uint8	hrs	0-240	0	0.1	0
Day_view_angle	View zenith angle of daytime Land-surface Temperature	uint8	deg	V3: 0-180	0	0.5	0

					255	1.0	-65.0
				V4: 0-130			
LST_Night_1km	Daily nighttime 1km grid Land-surface Temperature	uint16	K	7500-65535	0	0.02	0.0
QC_Night	Quality control for nighttime LST and emissivity	uint8	none	0-255	0	NA	NA
Night_view_time	(local solar) Time of nighttime Land-surface Temperature observation	uint8	hrs	0-240	0	0.1	0
Night_view_angle	View zenith angle of nighttime Land-surface Temperature	uint8	deg	V3: 0-180 V4: 0-130	0 255	0.5 1.0	0 -65.0
Emis_31	Band 31 emissivity	uint8	none	1-255	0	0.002	0.49
Emis_32	Band 32 emissivity	uint8	none	1-255	0	0.002	0.49
Clear_day_cov	day clear-sky coverage	uint16	none	0-65535	0	*0.0001	0.
Clear_night_cov	night clear-sky coverage	uint16	none	0-65535	0	*0.0001	0.
** Columns_per_ Global_Grid_Row	Columns per row in the MODLAND integerized sinusoidal grid	int32	none	0-43200	0	1	0

* The scale_factor 0.0001 was changed to 0.0004 since v2.3.6 and to 0.0005 since v2.5.1.

** SDS Columns_per_Global_Grid_Row is no longer included in the collection 3 MOD11A1.

3.3. Local Attributes

The local attributes for SDSs LST_Day_1km and LST_Night_1km are similar to those in Table 4.

3.4. Global Attributes

Three ECS global attributes and 12 product-specific global attributes are stored as metadata. The ECS global attributes, *CoreMetadata.0*, *ArchiveMetadata.0* and *StructMetadata.0* are stored as very long character strings in PVL format.

CoreMetadata.0 contains information about the product during production and is used to populate the EOSDIS data base for user support. A listing of objects along with sample values is given in Table 10.

Table 10. *CoreMetadata.0* of the MOD11A1 data product.

Object Name	Sample Value	Comment
ShortName	"MOD11A1"	ESDT name of

		product
VersionID	1	ESC Version
ReprocessingActual	"processed once"	Number of times processed.
ReprocessingPlanned	"further update is anticipated"	Expect that products will be reprocessed one or more times
LocalGranuleID	"MOD11A1.A2000207.h09v05.002.2000246..hdf"	Name of the granule.
DayNightFlag	"Both"	
ProductionDateTime	"2000-08-30T05:32:43.000Z"	Time granule was produced.
LocalVersionID	"SCF V2.2.16"	Version of algorithm delivered from the SCF
PGEVersion	"2.2.16"	Version of PGE in MODAPS.
InputPointer	"MOD03.A2000207.1915...hdf", "MOD021KM.A2000207...hdf", ...	Location of input files in the production system
RangeBeginningDate	"2000-07-25"	Beginning and ending times of the first and last scan line in the swath
RangeBeginningTime	"19:16:40.322353"	
RangeEndingDate	"2000-07-05"	
RangeEndingTime	"19:18:11.904997"	
ExclusionGRingFlag	"N"	latitude and

GringPointLatitude	[39.995833, 39.995833, 30.004167, 30.004167]	longitude values of the corner grids in the tile
GringPointLongitude	[-117.474532, -104.421223, -92.374445, -103.921832]	
GringPointSequenceNo	[1, 2, 3, 4]	
ParameterName	"MOD 1KM L3 LST"	Parameter for which QA statistics are given in this metadata object.
AutomaticQualityFlag	"Passed"	Result of automated checks done on the data during a run of algorithm. Useful for screening for anomalous data.
AutomaticQualityFlagExplanation	"Passed if algorithm ran within bounds of execution constraints. Suspect if bounds of execution constraints violated. Failed if PGE failed."	Explanation of result of automated QA checks made during execution.
ScienceQualityFlag	"Suspect"	Set by LST investigator after post-production investigation
SciencelQualityFlagExplanation	"Early product assessment is on going. Users are advised to use caution applying these data to project-applications, especially in semi-arid and arid areas. Input product are still being refined."	Explanation of Science Flag

QAPercentMissingData	0	0 - 100
QAPercentCloudCover	95	0 - 100
AssociatedPlatformShortName	"AM-1"	
AssociatedInstrumentShortName	"MODIS"	
AssociatedSensorShortName	"CCD"	
Product Specific Attributes (PSA)		
QAPercentGoodQuality	5	Summary quality assurance statistic for data product. (0 - 100)
QAPercentOtherQuality	0	
QAPercentNotProducedCloud	95	
QAPercentNotproducedOther	0	
N_GRAN_POINTERS	"5"	the number of granules considered for the tile
HorizontalTileNumber	"09"	
VerticalTileNumber	"05"	
TileID	"11009005"	
QAFractionGoodQuality	0.0536014	Summary fraction of the LST product. Range is from 0.0 to 1.0.
QAFractionOtherQuality	0.0000000	
QAFractionNotProducedCloud	0.9463986	
QAFractionNotProducedOther	0.0000000	

The ECS global attribute *ArchiveMetadata.0* contains information relevant to the input data, an alternate geographic coverage bounds, and information relevant to version of the algorithm and product. A listing of objects along with sample values is given in Table 11.

Table 11. *ArchiveMetadata.0* of the MOD11A1 data product.

Object Name	Sample Value	Comment
HorizontalTileNumber	"09"	
VerticalTileNumber	"05"	
AlgorithmPackageAcceptanceDate	"1997-11-01"	Algorithm Descriptors
AlgorithmPackageMaturityCode	"pre-launch"	

AlgorithmPackageName	"MOD_PR11_V2"	
AlgorithmPackageVersion	"Version 2"	
InstrumentName	"Moderate-Resolution Imaging SpectroRadiometer"	
ProcessingDateTime	"2000-08-30T05:32:43.000Z"	
LongName	"MODIS Level-3 1km Land Surface Temperature and Emissivity"	
ProcessingCenter	"GSFC"	
SPSOParameters	"2484 and 3323"	
LocalInputGranuleID	"1915"	only keep the time ID
EastBoundingCoordinate	-92.374445	Extent of the tile coverage.
WestBoundingCoordinate	-117.474532	
NorthBoundingCoordinate	39.995833	
SouthBoundingCoordinate	30.004167	

The *StructMetadata.0* global attribute is used by the HDF-EOS toolkit to create the mapping relationships between the defined grid and data (SDSs).

Table 12. Listing of objects in the global attribute *StructMetadata.0* in MOD11A1.

Object	Definition
DIMENSION_1	XDim = 1200
DIMENSION_2	YDim = 1200
DataField_1	DataFieldName=LST_Day_1km
DataField_2	DataFieldName=QC_Day
DataField_3	DataFieldName=Day_view_time
DataField_4	DataFieldName=Day_view_angle
DataField_5	DataFieldName=LST_Night_1km
DataField_6	DataFieldName=QC_Night
DataField_7	DataFieldName=Night_view_time
DataField_8	DataFieldName=Night_view_angle
DataField_9	DataFieldName=Emis_31
DataField_10	DataFieldName=Emis_32

DataField_11	DataFieldName=Clear_day_cov
DataField_12	DataFieldName=Clear_night_cov
DataField_13	DataFieldName=Columns_per_Global_Grid_Row

3.5. Quality Assurance

The bit flags defined for the quality assurance SDSs QC_day and QC_Night are listed in Table 13.

Table 13. Bit flags defined for SDSs QC_day and QC_Night in MOD11A1. Note that bit 0 is the least significant bit.

A - in V3

bits	Long Name	Key

1 & 0	Mandatory QA flags	00=LST produced, good quality, not necessary to examine
		  more detailed QA
		01=LST produced, other quality, recommend examination of
		  more detailed QA
		10=LST not produced due to cloud effects
		11=LST not produced primarily due to reasons other than cloud
		  (such as ocean grid, grid not covered by all processed granules)

3 & 2	Data quality flag	00=good data quality 01=LST affected by thin cirrus and/or sub-pixel clouds 10=not processed due to missing pixels 11=not processed due to poor quality
5 & 4	Emis Error flag	00=average emissivity error <= 0.01 01=average emissivity error <= 0.02 10=average emissivity error <= 0.04 11=average emissivity error > 0.04
7 & 6	LST LST Error flag	00=average LST error <= 1K 01=average LST error <= 2K 10=average LST error <= 3K 11=average LST error > 3K

B - in V4

bits	Long Name	Key

1 & 0	Mandatory QA flags	00=LST produced, good quality, not necessary to examine
		  more detailed QA
		01=LST produced, other quality, recommend examination of
		  more detailed QA
		10=LST not produced due to cloud effects
		11=LST not produced primarily due to reasons other than cloud

3 & 2	Data quality flag	00=good data quality 01=other quality data 10=TBD 11=TBD

5 & 4	Emis Error flag	00=average emissivity error <= 0.01 01=average emissivity error <= 0.02 10=average emissivity error <= 0.04 11=average emissivity error > 0.04
7 & 6	LST LST Error flag	00=average LST error <= 1K 01=average LST error <= 2K 10=average LST error <= 3K 11=average LST error > 3K

4. MOD11A2 Eight-day LST

An eight-day compositing period was chosen because twice of such period is the exact ground track repeat period of the Terra platform. LST over eight days is the averaged LSTs of the MOD11A1 product over eight days.

4.1. Algorithm Description

A simple average method is used in the current algorithm for the MOD11A2 product.

4.2. Scientific Data Sets

In the V3 MOD11A2 product, the SDSs are similar to those in the MOD11A1 product described in Table 9. In the V4 MOD11A2 product, the 12 SDSs are LST_Day_1km, QC_Day, Day_view_time, Day_view_angl, LST_Night_1km, QC_Night, Night_view_time, Night_view_angl, Emis_31, Emis_32, Clear_sky_days and Clear_sky_nights. The first ten SDSs are similar to those in the MOD11A1 product described in Table 9. The last two SDSs, Clear_sky_days and Clear_sky_nights, are similar to those in the 8-day CMG product described in Table 18.

4.3. Local Attributes

Similar to MOD11A1.

4.4. Global Attributes

Similar to MOD11A1.

4.5. Quality Assurance

Similar to MOD11A1.

5. MOD11B1 Daily LST

The daily level 3 LST product at 5km spatial resolution is a tile of daily LST product gridded in the Integerized Sinusoidal projection. A tile contains 240 by 240 grids in 240 rows and 240 columns. The exact grid size at 5km spatial resolution is 4.64km by 4.64km.

5.1. Algorithm Description

The daily MOD11B1 LST product is constructed with the results produced by the day/night LST algorithm (Wan and Li, 1997). New refinements implemented in the V4 LST processing include: updating the look-up tables (LUT) used in the day/night LST algorithm, processing inland water pixels in clear-sky when cloud mask reports a clear confidence of 66% and higher, using the 5km resolution MODIS 16-day BRDF Albedo Parameters product (MOD43B1C) as input, separating the range of viewing zenith angles into five sub-ranges (0-24, 24-38, 38-49, 49-58, and 58-65 degrees) instead of four in V3, parallelly processing data in odd and even days to double the production rate and the storage of interim results (for two sets of day and night observations in each view angle sub-range) for the day/night algorithm, incorporating a split-window method into the day/night algorithm to ensure that the retrieved emissivities can be used by split-window algorithms, and supporting for the SIN grid. These refinements and better qualities of input products improve the V4 MODIS LST products significantly.

The day/night LST algorithm in both V3 and V4 processings only uses those day and night MODIS observations: the day observations with solar zenith angle not larger than 75 degrees and the night observations with solar zenith angle larger than 90 degrees (i.e., no solar radiation in the night observations).

It should be noted that a new constraint was added to the day/night LST algorithm in the V4 code: the time difference between the day and night observations cannot be longer than 32 days. This constraint significantly limits the LST/emissivity retrieval in the polar regions.

5.2. Scientific Data Sets (SDS)

The SDSs in the MOD11B1 product include LST_Day_5km, QC_Day, Day_view_time, Day_view_angl, LST_Night_5km, QC_Night, Night_view_time, Night_view_angl, Emis_20, Emis_22, Emis_23, Emis_29, Emis_31, Emis_32, LST_Day_5km_Aggregated_from_1km and LST_Night_5km_Aggregated_from_1km. The last two SDSs are used for global browse imagery. Their details are shown in Table 14.

Table 14. The SDSs in the MOD11B1 product.

SDS Name	Long Name	Number Type	Unit	Valid Range	Fill Value	scale factor	add offset
LST_Day_5km	Daily daytime 5km grid Land-surface Temperature	uint16	K	7500-65535	0	0.02	0.0
QC_Day	Quality control for daytime LST and emissivity	uint8	none	0-255	0	NA	NA
Day_view_time	(local solar) Time of daytime Land-surface Temperature observation	uint8	hrs	0-120	0	0.2	0
* Day_view_angle	View zenith angle of daytime Land-surface Temperature	uint8	deg	V3: 0-180 V4: 0-130	0 255	0.5 1.0	0 -65.0
LST_Night_5km	Daily nighttime 5km grid Land-surface Temperature	uint16	K	7500-65535	0	0.02	0.0
QC_Night	Quality control for nighttime LST and emissivity	uint8	none	0-255	0	NA	NA
Night_view_time	(local solar) Time of nighttime Land-surface Temperature observation	uint8	hrs	0-120	0	0.2	0
* Night_view_angle	View zenith angle of nighttime Land-surface Temperature	uint8	deg	V3: 0-180 V4: 0-130	0 255	0.5 1.0	0 -65.0
Emis_20	Band 20 emissivity	uint8	none	1-255	0	0.002	0.49
Emis_22	Band 22 emissivity	uint8	none	1-255	0	0.002	0.49
Emis_23	Band 23 emissivity	uint8	none	1-255	0	0.002	0.49
Emis_29	Band 29 emissivity	uint8	none	1-255	0	0.002	0.49
Emis_31	Band 31 emissivity	uint8	none	1-255	0	0.002	0.49
Emis_32	Band 32 emissivity	uint8	none	1-255	0	0.002	0.49
LST_Day_5km_Aggregated_from_1km	Daily daytime 5km grid LST aggregated from 1km	uint16	K	7500-65535	0	0.02	0.
LST_Night_5km_Aggregated_from_1km	Daily nighttime 5km grid LST aggregated from 1km	uint16	K	7500-65535	0	0.02	0.
** QC_Emis	Quality control for retrieved emissivities	uint8	none	0-255	0	na	na

* In V4, a negative sign before the zenith view angle indicates that the MODIS views the Earth surface from east.

** The first four bits (00-03) are used as nighttime view angle flag to show the index of view angle sub-range of the nighttime observation used in the emissivity retrieval. Other four bits (04-07) are used as daytime view angle flag to show the index of the daytime view angle sub-range. The view angle sub-range index has a value of 0, 1, 2, 3, or 4, indicating the view angle in sub-ranges 0-24, 24-38, 38-49, 49-58, or 58-65 degrees.

5.3. Local Attributes

The local attributes for SDSs LST_Day_5km and LST_Night_5km are similar to those in Table 4.

5.4. Global Attributes

Three ECS global attributes and 16 product-specific global attributes are stored as metadata. The ECS global attributes, *CoreMetadata.0*, *ArchiveMetadata.0* and *StructMetadata.0* are stored as very long character strings in PVL format.

CoreMetadata.0 contains information about the product during production and is used to populate the EOSDIS data base for user support. They are similar to those of MOD11A1.

5.5. Quality Assurance

The bit flags defined for the quality assurance SDSs QC_day and QC_Night in MOD11B1 are listed in Table 15.

Table 15. Bit flags defined for SDSs QC_day and QC_Night in MOD11B1. Note that bit 0 is the least significant bit.

A - in V3

bits	Long Name	Key
1 & 0	Mandatory QA flags	00=LST produced, good quality, not necessary to examine more detailed QA 01=LST produced, other quality, recommend examination of more detailed QA 10=LST not produced due to cloud effects 11=LST not produced primarily due to reasons other than cloud (such as ocean grid, grid not covered by all processed granules)
3 & 2	Data quality flag	00=good data quality 01=other quality data 10=LST affected by thin cirrus and/or sub-grid clouds 11=not processed due to no pair of day/night data
5 & 4	Emis Error flag	00=average emissivity error <= 0.01 01=average emissivity error <= 0.02 10=average emissivity error <= 0.04 11=average emissivity error > 0.04
7 & 6	LST LST Error flag	00=average LST error <= 1K

		01=average LST error <= 2K
		10=average LST error <= 3K
		11=average LST error > 3K

B - in V4

bits	Long Name	Key
1 & 0	Mandatory QA flags	00=LST produced, good quality, not necessary to examine more detailed QA 01=LST produced, other quality, recommend examination of more detailed QA 10=LST not produced due to cloud effects 11=LST not produced primarily due to reasons other than cloud
3 & 2	Data quality flag	00=good data quality 01=other quality data 10=LST affected by nearby clouds and/or sub-grid clouds and/or ocean 11=TBD
5 & 4	Emis Error flag	00=average emissivity error <= 0.01 01=average emissivity error <= 0.02 10=average emissivity error <= 0.04 11=average emissivity error > 0.04
7 & 6	LST LST Error flag	00=average LST error <= 1K 01=average LST error <= 2K 10=average LST error <= 3K 11=average LST error > 3K

6. MOD11C1 Daily CMG LST

This daily global LST product provides temperature and emissivity values at 0.05 degree latitude/longitude climate model grids (CMG). The exact areal size of the equal angle grids varies with latitude, and it is 5.6km by 5.6km at the Equator.

6.1. Algorithm Description

The temperature and emissivity values in MOD11C1 are derived by reprojection and average of the values in the daily MODIS LST/E product (MOD11B1) at 5km equal area grids in the sinusoidal projection. Before making reprojection in the production of MOD11C1, cloud-contaminated daytime and nighttime LSTs are removed by the double-screen scheme, which is described in the LST validation paper (Wan et al., 2002). In the first step, the temperature difference distributions between the LSTs at 5km grids retrieved by the day/night LST algorithm and the LST values aggregated to 5km grids

from those retrieved by the generalized split-window algorithm are calculated for all grids in northern or southern hemisphere, for daytime and nighttime LSTs, respectively. The LSTs which correspond to the 1% of the difference distributions by the upper and lower ends are removed. In the second step, the histogram of difference between daytime and nighttime LSTs is used to remove the grids contaminated with cloud effects after the first screen described above: screen off 0.5% of the daytime and nighttime LST pairs by the upper and lower ends of the LST difference distribution. The retrieved emissivity values corresponding to these removed LSTs are also removed. After cloud-contaminated daytime and nighttime LSTs are removed, the LST values aggregated to 5km grids from those retrieved by the generalized split-window algorithm are used to supplement the LSTs retrieved by the day/night LST algorithm at grids where there is no valid pair of day and night observations (usually in high-latitude regions). Due to this LST supplement, the spatial coverages of LSTs are larger than the spatial coverage of retrieved emissivities in the MOD11C products.

6.2. Scientific Data Sets (SDS)

There are 15 SDSs in the MOD11C1 product as shown in Table 16.

Table 16. The SDSs in the MOD11C1 product.

SDS Name	Long Name	Number Type	Unit	Valid Range	Fill Value	scale factor	add offset
LST_Day_CMG	Daily daytime 3min CMG Land-surface Temperature	uint16	K	7500-65535	0	0.02	0.0
QC_Day	Quality control for daytime LST and emissivity	uint8	none	0-255	0	NA	NA
Day_view_time	Time of daytime Land-surface Temperature observation (UTC)	uint8	hrs	0-120	0	0.2	0
Day_view_angle	View zenith angle of daytime Land-surface Temperature	uint8	deg	0-130	255	1.0	-65.0
LST_Night_CMG	Daily nighttime 3min CMG Land-surface Temperature	uint16	K	7500-65535	0	0.02	0.0
QC_Night	Quality control for nighttime LST and emissivity	uint8	none	0-255	0	NA	NA
Night_view_time	Time of nighttime Land-surface Temperature observation (UTC)	uint8	hrs	0-120	0	0.2	0
Night_view_angle	View zenith angle of nighttime Land-surface Temperature	uint8	deg	0-130	255	1.0	-65.0
Emis_20	Band 20 emissivity	uint8	none	1-255	0	0.002	0.49
Emis_22	Band 22 emissivity	uint8	none	1-255	0	0.002	0.49
Emis_23	Band 23 emissivity	uint8	none	1-255	0	0.002	0.49
Emis_29	Band 29 emissivity	uint8	none	1-255	0	0.002	0.49

Emis_31	Band 31 emissivity	uint8	none	1-255	0	0.002	0.49
Emis_32	Band 32 emissivity	uint8	none	1-255	0	0.002	0.49
QC_Emis *	Quality control for retrieved emissivities	uint8	none	0-255	0	na	na

Note *: bits 00-03, nighttime view angle flag, for the index of nighttime view angle sub-range; and bits 04-07, daytime view angle flag, for the index of daytime view angle sub-range.

6.3. Local Attributes

The local attributes for SDSs LST_Day_CMG and LST_Night_CMG are similar to those in Table 4.

6.4. Global Attributes

Three ECS global attributes and 16 product-specific global attributes are stored as metadata. The ECS global attributes, *CoreMetadata.0*, *ArchiveMetadata.0* and *StructMetadata.0* are stored as very long character strings in PVL format.

CoreMetadata.0 contains information about the product during production and is used to populate the EOSDIS data base for user support. They are similar to those of MOD11A1.

6.5. Quality Assurance

The bit flags in the QC SDS are listed in Table 17 .

Table 17. Bit flags defined in the QC SDS in the MOD11C1 product. Note that bit 0 is the least significant bit.

bits	Long Name	Key
1 & 0	Mandatory QA flags	00=LST produced, good quality, not necessary to examine more detailed QA 01=LST produced, other quality quality, recommend examination of more detailed QA 10=LST not produced due to cloud effects 11=LST not produced primarily due to reasons other than cloud
3 & 2	Data quality flag	00=good data quality 01=other data quality pixel 10=LST affected by nearby clouds and/or sub-grid clouds and/or ocean 11=LST screened off
5 & 4	Emis Error flag	00=average emissivity error <= 0.01 01=average emissivity error <= 0.02 10=average emissivity error <= 0.04 11=average emissivity error > 0.04
7 & 6	LST Error flag	00=average LST error <= 1K 01=average LST error <= 2K 10=average LST error <= 3K 11=average LST error > 3K

7. MOD11C2 8-Day CMG LST

This LST product provides 8-day composited and averaged temperature and emissivity values at 0.05 degree latitude/longitude grids (CMG), as well as the averaged observation times and viewing zenith angles for daytime and nighttime LSTs.

7.1. Algorithm Description

The temperature and emissivity values in the MOD11C1 product over a period of 8 days are simply composited and averaged. The days and nights in clear-sky conditions and with validated LSTs are flagged in each bit of two 8-bit unsigned integers (one for daytime LSTs and another for nighttime LSTs).

7.2. Scientific Data Sets (SDS)

There are 16 SDSs in the MOD11C2 product as shown in Table 18.

Table 18. The SDSs in the MOD11C2 product.

SDS Name	Long Name	Number Type	Unit	Valid Range	Fill Value	scale factor	add offset
LST_Day_CMG	8-day daytime 3min CMG Land-surface Temperature	uint16	K	7500-65535	0	0.02	0.0
QC_Day	Quality control for daytime LST and emissivity	uint8	none	0-255	0	NA	NA
Day_view_time	Averaged time of daytime LST observation (UTC)	uint8	hrs	0-120	0	0.2	0
Day_view_angle	Averaged view zenith angle of daytime Land-surface Temperature	uint8	deg	0-130	255	1.0	-65.0
* Clear_sky_days	the days in clear-sky conditions and with validate LSTs	uint8	none	0-255	0	na	na
LST_Night_CMG	8-day nighttime 3min CMG Land-surface Temperature	uint16	K	7500-65535	0	0.02	0.0
QC_Night	Quality control for nighttime LST and emissivity	uint8	none	0-255	0	NA	NA
Night_view_time	Averaged time of nighttime LST observation (UTC)	uint8	hrs	0-120	0	0.2	0
Night_view_angle	Averaged view zenith angle of nighttime Land-surface Temperature	uint8	deg	0-130	255	1.0	-65.0
* Clear_sky_nights	the nights in clear-sky conditions and with validate LSTs	uint8	none	0-255	0	na	na
Emis_20	Band 20 emissivity	uint8	none	1-255	0	0.002	0.49
Emis_22	Band 22 emissivity	uint8	none	1-255	0	0.002	0.49
Emis_23	Band 23 emissivity	uint8	none	1-255	0	0.002	0.49
Emis_29	Band 29 emissivity	uint8	none	1-255	0	0.002	0.49

Emis_31	Band 31 emissivity		uint8	none	1-255	0	0.002	0.49
Emis_32	Band 32 emissivity		uint8	none	1-255	0	0.002	0.49

* Each bit in the 8-bit unsigned integer indicates clear-sky (1) or not (0) in the corresponding day or night. Bit 00 is for the first day or night, and bit 07 is for the last day or night in the 8-day period.

7.3. Local Attributes

The local attributes for SDSs LST_Day_CMG and LST_Night_CMG are similar to those in Table 4.

7.4. Global Attributes

Three ECS global attributes and 16 product-specific global attributes are stored as metadata. The ECS global attributes, *CoreMetadata.0*, *ArchiveMetadata.0* and *StructMetadata.0* are stored as very long character strings in PVL format.

CoreMetadata.0 contains information about the product during production and is used to populate the EOSDIS data base for user support. They are similar to those of MOD11A1.

7.5. Quality Assurance

The bit flags in the QC SDS are similar to those in Table 17.

8. MOD11C3 Monthly CMG LST

This LST product provides monthly composited and averaged temperature and emissivity values at 0.05 degree latitude/longitude grids (CMG), as well as the averaged observation times and viewing zenith angles for daytime and nighttime LSTs.

8.1. Algorithm Description

The temperature and emissivity values in the MOD11C1 product in a calendar month are simply composited and averaged. The days and nights in clear-sky conditions and with validated LSTs are flagged in each bit of two 32-bit unsigned integers (one for daytime LSTs and another for nighttime LSTs).

8.2. Scientific Data Sets (SDS)

There are 16 SDSs in the MOD11C3 product as shown in Table 19.

Table 19. The SDSs in the MOD11C3 product.

SDS Name	Long Name	Number Type	Unit	Valid Range	Fill Value	scale factor	add offset
LST_Day_CMG	Monthly daytime 3min CMG Land-surface Temperature	uint16	K	7500-65535	0	0.02	0.0
QC_Day	Quality control for daytime LST and emissivity	uint8	none	0-255	0	NA	NA
Day_view_time	Averaged time of daytime LST observation (UTC)	uint8	hrs	0-120	0	0.2	0
Day_view_angle	Averaged view zenith angle of daytime Land-surface Temperature	uint8	deg	0-130	255	1.0	-65.0
Clear_sky_days	the days in clear-sky conditions and with validate LSTs	uint32	none	0-4294967296	0	na	na
LST_Night_CMG	Monthly nighttime 3min CMG Land-surface Temperature	uint16	K	7500-65535	0	0.02	0.0
QC_Night	Quality control for nighttime LST and emissivity	uint8	none	0-255	0	NA	NA
Night_view_time	Averaged time of nighttime LST observation (UTC)	uint8	hrs	0-120	0	0.2	0
Night_view_angle	Averaged view zenith angle of nighttime Land-surface Temperature	uint8	deg	0-130	255	1.0	-65.0
Clear_sky_nights	the nights in clear-sky conditions and with validate LSTs	uint32	none	0-4294967296	0	na	na
Emis_20	Band 20 emissivity	uint8	none	1-255	0	0.002	0.49
Emis_22	Band 22 emissivity	uint8	none	1-255	0	0.002	0.49
Emis_23	Band 23 emissivity	uint8	none	1-255	0	0.002	0.49
Emis_29	Band 29 emissivity	uint8	none	1-255	0	0.002	0.49
Emis_31	Band 31 emissivity	uint8	none	1-255	0	0.002	0.49
Emis_32	Band 32 emissivity	uint8	none	1-255	0	0.002	0.49

8.3. Local Attributes

The local attributes for SDSs LST_Day_CMG and LST_Night_CMG are similar to those in Table 4.

8.4. Global Attributes

Three ECS global attributes and 16 product-specific global attributes are stored as metadata. The ECS global attributes, *CoreMetadata.0*, *ArchiveMetadata.0* and *StructMetadata.0* are stored as very long character strings in PVL format.

CoreMetadata.0 contains information about the product during production and is used to populate the EOSDIS data base for user support. They are similar to those of MOD11A1.

8.5. Quality Assurance

The bit flags in the QC SDS are similar to those in Table 17.

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