MODIS Sea Ice Products

User Guide to

Collection 6

George A. Riggs

Dorothy K. Hall

17 March 2015

Table of Contents

Overview

The MODIS sea ice extent and ice surface temperature (IST) algorithms and data products for Collection 6 (C6) are essentially the same as those in Collection 5 (C5).   Evaluation of the sea ice products and review of literature have found the products to be accurate within limitations of algorithms and sensor capabilities, based on that information there were no reasons to make significant revisions to the algorithms or data products.   Recently there has been increased interest in and use of the IST products, that usage is being watched and evaluated. Future revisions to the algorithms and data products will be based on information from the literature, users' experience and evaluation and validation of the products. Notable in C6 are the revisions made in the MODIS data products used as input to the sea ice algorithm that have resulted in improvements in the sea ice outputs, which are noted in relevant sections of the guide.

Revisions and improvements in C6 MODIS L1B calibration, the MODIS land and water mask, and the C6 cloud mask products have affected output of the sea ice algorithms.

The MODIS Calibration Support Team (MCST) (landweb.nascom.nasa.gov/cgi-bin/QA_WWW/newPage.cgi?fileName=C6_final_change) revised calibration of the thermal bands 31 and 32 which resulted in decreasing the calculated brightness temperature by about -0.01 K and improved accuracy for very cold scenes (especially below ~ -30°C). In science tests of the MOD29 IST algorithm with MOD021KM C6 inputs differences in IST in range of +/- 0.1 K were found compared to the IST made with C5 across all conditions, 97% of all differences where in that range.   The estimated IST remains in the estimated accuracy range of 3 K.

The C6 MODIS land/water mask, stored in the geolocation product, MOD03, has greatly increased accuracy of mapping water bodies and coastlines (landweb.nascom.nasa.gov/QA_WWW/forPage/MODIS_C6_WaterMak_v3.pdf). In polar regions there is a notable improvement in the location of coastlines in the sea ice products due to the improved accuracy of the land/water mask.

Revisions in the MODIS cloud mask algorithm (modis-atmos.gsfc.nasa.gov/products_C006update.html) generally increased accuracy of cloud detection. We have noticed improved cloud detection in some situations relative to sea ice, usually very localized in daytime scenes; difference in total cloud amount is usually in range of 1-3% but may range up to 10%. The cloud mask uses a new night time ocean test that enhanced detection of low level and cirrus clouds (Baum et.al., 2012)which may decrease cloud and sea ice confusion in the IST night time maps.

Both MODIS Terra and MODIS Aqua versions of the sea ice products are generated. Though this user guide applies to products generated from both sensors but is written based primarily on the Terra products. The bias to Terra is because the visible bands sea ice detection algorithm is based on use of visible and near infrared data at 1.6 μm. A primary key to sea ice detection is the characteristic of snow covered sea ice to have high visible reflectance and low reflectance in the near infrared, MODIS band 6. MODIS band 6 (1.6 μm) on Terra is fully functional however, MODIS band 6 on Aqua is only about 30% functional; 70% of the band 6 detectors non-

functional. That situation on the MODIS Aqua necessitated the change to use band 7 (2.1 μm) for sea ice mapping in the swath level algorithm instead of band 6. The bias to Terra is also because of the greater understanding of the MODIS Terra sensor, pre-launch algorithm development, longer data record of Terra and greater amount of testing the Terra algorithms in preparation for processing. The ice surface temperature (IST) algorithm is the same for both Terra and Aqua because the thermal bands are essentially the same on both MODIS sensors. Discussion of reasons for the different bands and the effect on sea ice mapping are beyond the scope of this user guide but are discussed in the MODIS sea ice ATBD (modis-snow-ice.gsfc.nasa.gov/). The Level-3 product algorithms are the same for Terra and Aqua. Similarities and differences between Terra and Aqua are presented in the product sections.

The guide is organized into sections for each data product with subsections on the algorithm and scientific data sets (SDSs) and metadata stored in products and a brief discussion of the accuracy, error and evaluation of the products.

Sea Ice Data Products

The MODIS sea ice products are generated as a sequence of products beginning at the swath level then progressing through spatial and temporal transformations to a daily global gridded sea ice product. The sea ice extent product is made for daytime data using MODIS visible bands. The IST product is made for daytime and nighttime using MODIS thermal bands. Sea ice detection and IST algorithms are applied in Level-2 processing (swath level), the higher level algorithms and products are generated by compositing spatially or temporally the preceding product. Each sea ice product in the sequence after the swath product assimilates accuracy and error from the preceding product. A user should understand that the accuracy and quality of a product is affected by the previous level(s) of input products. Understanding the assimilation of accuracy and error between levels and through higher levels is necessary to optimize use of the products. A description of assimilated error and how it affects the accuracy of the product is included in each product section. A user may want to study the preceding product(s) description to enhance their understanding of the product accuracy at a particular level.

Sea ice data products are produced as a series of four products. The sequence begins At Level-2 with a swath (scene) at a nominal pixel spatial resolution of 1 km and nominal swath coverage of 1354 km (cross track) by 2030 km (along track, five minutes of MODIS scans). A summarized listing of the sequence of products is given in Table 1. Products in the Earth Observing System Data and Information System (EOSDIS) are labeled as Earth Science Data Type (ESDT), the ESDT label *ShortName* is used to identify the sea ice data products. Except for the initial sea ice product, MOD29, each sea ice product in the sequence is made using the previous sea ice product as input. These sea ice products are identified, in part, by product levels in EOSDIS that 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-2G (L2G) product is a gridded format of a map projection. At L2G the data products are referred to as tiles, each tile being a piece, e.g. 10° x 10° area, of a map projection. Level-2 data products are gridded into L2G tiles by mapping the L2 pixels into cells of a tile. The L2G algorithm creates a gridded product necessary for the level 3 products. 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. Brief descriptions of the sea ice data products are given here to give perspective to the sequence. Expanded descriptions of the sea ice products are given in following sections.

The first product in the sequence is the MOD29 sea ice extent and ice surface temperature at 1 km spatial resolution for a swath. The sea ice extent is the result of the algorithm identifying sea ice and other features in the scene. The IST is calculated for all ocean pixels in a swath. The swath level sea ice data products may contain day, night or mix of day and night data. Daylight data is defined as data collected where the solar zenith angle is 0 to 85°. Night data is where solar zenith angle is > 85° or where MODIS is operating in night mode collecting only thermal data. Swaths in daylight or that cover the terminator contain sea ice extent and IST. Swaths acquired in night mode contain only IST data. Sea ice products are split into day and night products at L2G and L3. The split was made to reduce file size, L2G files could exceed the 2 Gbyte size limit over the poles because data from 1 – 14 orbits could possibly be contained in the file.

The L2G product is an intermediate multidimensional data product created by mapping the pixels from the MOD29 products for a day or night to their Earth locations on the Lambert Azimuthal equal area EASE-Grid projection (nsidc.org/data/ease/), thus multiple observations, i.e. pixels, covering a geographic location (cell) in the tile are "stacked" on one another. Two EASE-Grid projections, Northern and Southern Hemispheres are used for mapping. The projection is divided into 361 tiles covering each hemisphere. Information on how the pixels were mapped to the cells is stored in a pointer product associated with the L2G product.

The third product, MOD29P1D is daily daytime sea ice cover and IST at 1 km spatial resolution. From the multiple observations in a cell of the L2G product the observation selected for the daylight sea ice extent is the one that has the highest score from a scoring algorithm based on solar elevation, observation coverage in a cell and distance from nadir. For observations obtained in darkness where solar zenith angle > 85° sea ice extent data is excluded. The night time version of the product MOD29P1N has only the IST for observations obtained in darkness where solar zenith angle > 85° or when MODIS is operating in night mode, only thermal data acquired, and uses the scoring algorithm with solar elevation is omitted for selecting the IST observation .

The fourth product, MOD29E1D, is a daily global map of ice extent and IST at 4 km resolution generated from compositing of the MOD29P1D product tiles The ESDT names of the L2G and L3 products (Table 1) indicate if the data are from day or night. The naming convention for sea ice ESDT products is MOD29pto
Where,

p – is the projection

        P – polar, EASE-Grid

        E --EASE-Grid polar projection, hemispheres

t – is the level and/or time period covered

        G – level 2G

        1 - L3 daily

o – day or night

        N – night

        D – day

Table 1. Listing of the MODIS sea ice data products.

Earth Science Data Type (ESDT)	Product Level	Nominal Data Array Dimensions	Spatial Resolution	Temporal Resolution	Map Projection
MOD29	L2	1354 by 2030	1 km	swath (scene)	Latitude, longitude referenced
MOD29PGD	L2G	951 by 951	1 km	day of multiple coincident swath coverage	EASE-Grid polar
MOD29PGN	L2G	951 by 951	1 km	night of multiple coincident swath coverage	EASE-Grid polar
MOD29P1D	L3	951 by 951	1 km	day	EASE-Grid polar
MOD29P1N	L3	951 by 951	1 km	night	EASE-Grid polar
MOD29E1D	L3	4501 by x 4501	4 km	day	EASE-Grid polar, North and South

File Format of Sea Ice Products

The MODIS sea ice products are archived in Hierarchical Data Format – Earth Observing System (HDF-EOS) files. HDF, developed by the National Center for Supercomputer Applications (NCSA), is the standard archive format for EOS data (www.hdfgroup.org/projects/esdis/). The sea ice 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 and mapping 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, contain information about the data set. Users unfamiliar with HDF-EOS formats should consult the sites listed in the *Related Websites* section for more information.

Sea ice data product files contain Earth Science Data and Information System (ESDIS) global attributes. The ESDIS global attributes; CoreMetadata.0, ArchiveMetadata.0 and StructMetadata.0 contain information relevant to production, archiving, user services, geolocation and analysis of data. Geolocation and gridding relationships between HDF-EOS point, swath, and grid structures and the data are contained in the ECS global attribute StructureMetadata.0. Those 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. Products may also contain product specific attributes (PSAs) defined by the product developers. Output of the sea ice algorithms, e.g. sea ice extent and IST are stored as SDSs with local attributes. Local attributes describe data in an SDS. Detailed descriptions of each sea ice product are given in following sections.

Data products are generated in the MODIS Adaptive Processing System (MODAPS) using the HDF-EOS toolkit, Science Data Processing (SDP) Toolkit, HDF API and the C programming language. Various software tools available from the DAACs, open source software and commercial software tools/packages, are capable of accessing the HDF-EOS files.

MOD29

The MOD29 Level-2 product includes sea ice extent, ice surface temperature (IST) and QA data arrays for each, coarse resolution latitude and longitude data, and metadata. The content of a MOD29 product varies with day and night granules; sea ice extent is not estimated at night. The sea ice extent algorithm identifies ice-covered oceans by reflectance characteristics. Ice surface temperature (IST) is estimated by the split-window technique. For complete global coverage the MOD29 sea ice product is generated for all swaths acquired during a 24 hour period. An example of the MOD29 sea ice extent and IST from 14 July 2003 1550 UTC of the Barents Sea region is exhibited in Figures 1 and 2. The sea ice algorithm and data product contents are described in the following sections.
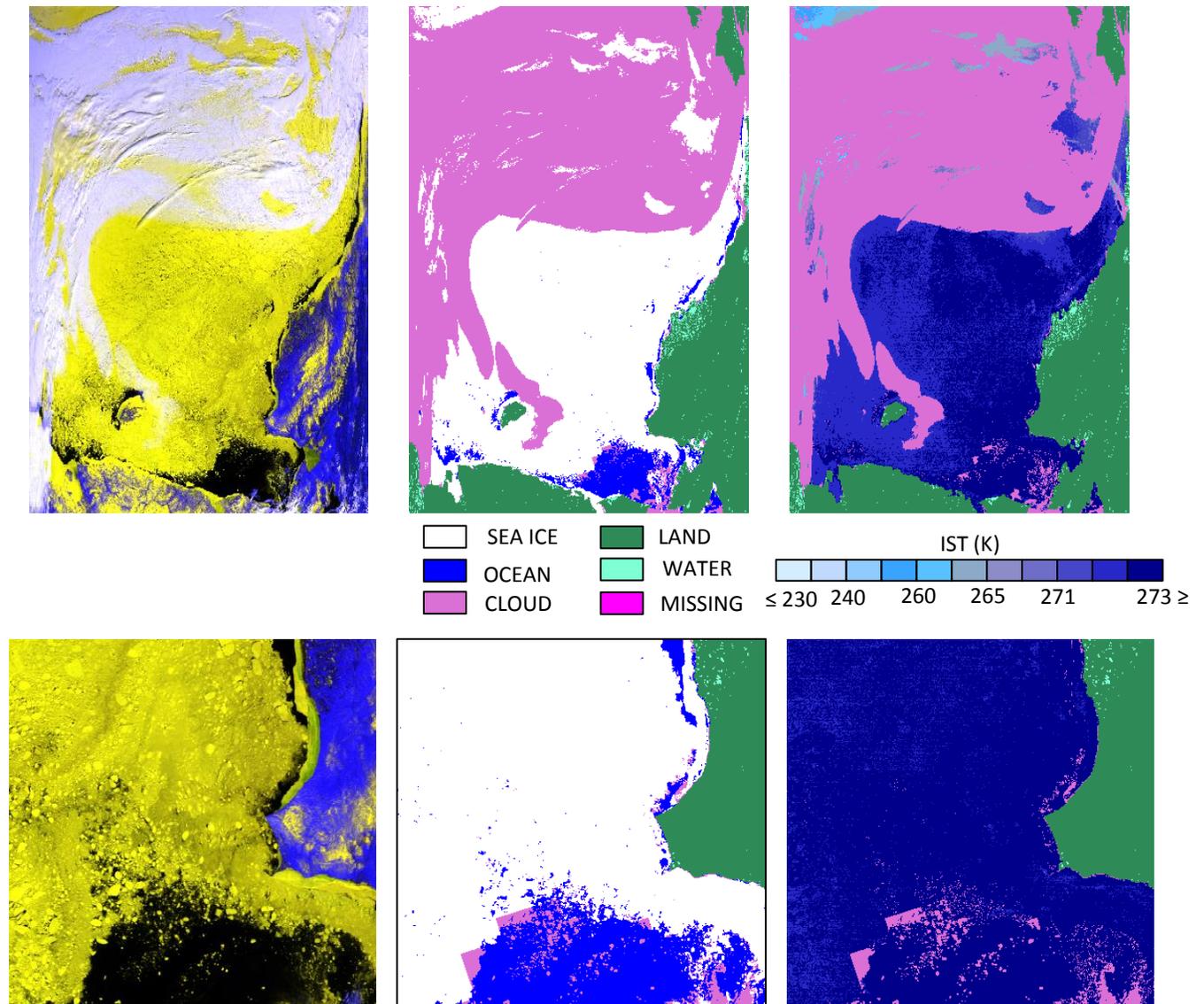
Figure 1.
MOD29. A2002143.2320.006.20142320034.hdf swath product of sea ice extent (top center image) and IST (top right image) of Arctic Ocean along Alaska and Russia coasts, Seward Peninsula is located on lower right corner of image. IST scale has narrower intervals over 265-273K to show detail in that temperature range. False color (bands 1, 4, 6) image of MOD021KM.A2002143.2320.006.2014232003420.hdf shown in left image for image interpretation. At 1km resolution details of sea ice extent can be seen in clear sky conditions. Subset images in the lower row, Chukchi Sea and Lisburne Peninsula AK on right side of subset, show some detail in the data.

Algorithm Description

A brief description of the sea ice algorithm is given for the purpose of aiding a user in understanding and interpreting the data product. Details of the sea ice algorithm can be found in the Algorithm Theoretical Basis Document (ATBD).

The sea ice extent algorithm is constrained to daylight ocean pixels that have visible reflectance above 10% and are not obstructed by clouds. Data inputs to the sea ice algorithm are listed in Table 2. The new C6 MODIS land/water mask is used to guide processing on oceans. The three categories of ocean -- deep, moderate and shallow -- in the land/water mask are processed as ocean; no distinction is made between categories. Top-of-the-atmosphere (TOA) reflectance data is read from the MOD021KM product. The MOD021KM data is screened for missing data and for unusable data. Unusable data results from processing at L1B when the sensor radiance data fails to meet acceptable criteria. MODIS data may be unusable for several reasons. Specifics of L1B processing and criteria can be found at the MODIS Calibration Support Team (MCST) web page and in supporting documentation. In the case of missing data, the algorithm maps the data as missing in the output product. No action is taken in the algorithm to make an analysis for missing data. If other anomalous conditions occur with the input data, the algorithm makes no decision for that pixel, except for a few anomalous conditions where a value indicating the source of the anomaly is written. Clouds are masked using the MODIS Cloud Mask data product (MOD35_L2) unobstructed field-of-view flag. If the cloud flag is set to certain cloud then the pixel is set to cloud. If the cloud flag is set to clear or any level of possible cloud the pixel is interpreted as clear. That logic is used to increase the number of retrievals balanced against the cloud conservative nature of the cloud mask, and accepts potential ice/cloud confusion and cloud contamination in IST.

Table 2. MODIS data product inputs to the MODIS sea ice algorithm.

ESDT	Long Name	Data Used
MOD021KM	MODIS Level 1B Calibrated and Geolocated Radiances	MODIS band (center wavelength) 1 (0.645 µm) 2 (0.865 µm) 4 (0.555 µm) 6 (1.640 µm) 31 (11.03 µm) 32 (12.02 µm)
MOD03	MODIS Geolocation	Land/Water Mask Solar Zenith Angles Sensor Zenith Angles Latitude Longitude
MOD35_L2	MODIS Cloud Mask	Unobstructed Field of View Flag

	Day/Night Flag

Sea ice detection is achieved through the use of grouped criteria tests for sea ice reflectance characteristics in the visible and near-infrared regions. Criteria for sea ice are that a pixel has a normalized difference snow index (NDSI), (band 4-band 6) / (band 4 + band 6) greater than 0.4 and visible reflectance in band 2 greater than 0.11 and band 1 reflectance greater than 0.10. If a pixel passes this group of criteria tests it is identified as sea ice and passed through more tests. Intermediate checks for theoretical bounding of reflectance data and the NDSI are made in the algorithm. In theory, reflectance values should lie within the 0-1 range and the NDSI ratio should lie within the -1.0 to +1.0 range. However, the test for sea ice is applied regardless of violations of these limits and the QA data is set to indicate an unusual condition with low quality result.

Ice surface temperature (IST) is calculated with a split-window technique using MODIS bands 31 and 32 radiance data. Coefficients for the IST equation were derived by Jeff Key, NOAA, using MODIS spectral response functions and radiative transfer calculations. Sets of coefficients are implemented for the Northern and Southern Hemispheres and for temperature ranges based on band 31 brightness temperature.   A different set of a, b, c, and d coefficients is used for each of three temperature ranges in the Northern and Southern Hemispheres separately. IST coefficients are given in Table 3.

$$IST = IST = a + bT_{11} + c(T_{11}-T_{12}) + d[(T_{11}-T_{12})(\sec(q)-1)]$$
where,

       T_{11} is brightness temperature at 11.03 µm
       T_{12} is brightness temperature at12.02 µm
       q is sensor scan angle
       a, b, c, d are regression coefficients.

Table 3. Coefficients used in the calculation of IST. The same coefficients are used for Terra and Aqua MODIS sensors.

Northern Hemisphere	a	b	c	d
< 240 K	-1.5711228087	1.0054774067	1.8532794923	-0.7905176303
240 – 260 K	-2.3726968515	1.0086040702	1.6948238801	-0.2052523236
> 260 K	-4.2953046345	1.0150179031	1.9495254583	0.1971325790
Southern Hemisphere	a	b	c	d
< 240 K	-0.1594802497	0.9999256454	1.3903881106	-0.4135749071
240 – 260 K	-3.3294560023	1.0129459037	1.2145725772	0.1310171301
> 260 K	-5.2073604160	1.0194285947	1.5102495616	0.2603553496

The IST algorithm is constrained to ocean pixels that are not obstructed by clouds and is run for both daytime and nighttime data. Data inputs to the sea ice algorithm are listed in Table 2. The new C6 MODIS land/water mask is used to guide processing on oceans. The three categories of ocean -- deep, moderate and shallow -- in the land/water mask are processed as ocean; no distinction is made between categories.   Radiance data for bands 31 and 32 are read from MOD021KM and converted to brightness temperature using the Planck function. The MOD021KM data is screened for missing data and for unusable data. Unusable data results from the processing at L1B when the sensor radiance data fails to meet acceptable criteria. MODIS data may be unusable for several reasons. Specifics of L1B processing and criteria can be found at the MODIS Calibration Support Team (MCST) web page and in supporting documentation. In the case of missing data, the algorithm maps the data as missing in the output product. No action is taken in the algorithm to make an analysis for missing data. If other anomalous conditions occur with the input data, the algorithm makes no decision for that pixel, except for a few anomalous conditions where a value indicating the source of the anomaly is written. Quality checks are applied to the input data and at intermediate processing steps, quality value is lowered if checks are failed, and the final quality value associated with a pixel is output. Clouds are masked using the MODIS Cloud Mask data product (MOD35_L2) unobstructed field-of-view flag for both daytime and nighttime data.   If the cloud flag is set to clear or any level of possible cloud the pixel is interpreted as clear. That logic is used to increase the number of retrievals balanced against the cloud conservative nature of the cloud mask, and accepts potential ice/cloud confusion and cloud contamination in IST.

Results of the sea ice algorithm are stored in SDSs in the product. The number of SDSs varies between swaths that have day, either day and night data or only night, i.e. only thermal data. There are also two SDSs of geolocation data. There are quality assessment SDSs for the sea ice extent and IST outputs.   Swaths that have day data in them have six SDSs. Swaths that have only nighttime data have only the IST and geolocation outputs. Each of the SDSs is described in the following subsections.

Quality Assessment

Quality assessment applied in the algorithm checks that the input data and intermediate calculated data values are within theoretical or expected ranges. A QA value is assigned based on the checks done. The default QA value is good result, QA=0. If any of the data checks are failed the QA value set to other quality, QA=1. If the algorithm was not applied, to pixel e.g. a land pixel, then a mask data value is output for the pixel. In the global attribute CoreMetadata.0 the ScienceQualityFlagExplanation is a pointer to website for more information on the science quality status of the product.

Scientific Data Sets

Sea_Ice_by_Reflectance
The sea ice extent product is stored as coded data values in the *Sea_Ice_by_Reflectance* SDS. The sea ice algorithm identifies pixels as sea ice, ocean, land, inland water, cloud or other

condition. A color-coded image of a sea ice extent swath image is shown in Figures 1 and 2. Predefined HDF and custom local attributes are included. Local attributes are listed in Table 4.

Table 4. Local attributes for the *Sea_Ice_by_Reflectance* SDS.

Attribute Name	Definition	Value
long_name	Long Name of the SDS	Sea ice by reflective characteristics
units	SI units of the data	none
format	Data type	I3
coordsys	Coordinate system to use for the data	Cartesian
valid_range	Max and min values for sea ice extent	0-254
_FillValue	Used to fill gaps in the swath	255
Key	Key to meaning of data in the SDS	0=missing data 1=no decision 11=night 25=land 37=inland water 39=ocean 50=cloud 100=lake ice 200=sea ice 254=detector saturated 255=fill
Nadir_data_resolution	Nominal spatial resolution of the pixels at nadir	1 km
Valid EV Obs Band 2 (%)	The percentage of valid observations from Level 1B in Band 2 in the swath	0.0 - 100.0
Valid EV Obs Band 4 (%)	The percentage of valid observations from Level 1B in Band 4 in the swath	0.0 - 100.0
Valid EV Obs Band 6 (%)	The percentage of valid observations from Level 1B in Band 6 in the swath	0.0 - 100.0
Saturated EV Obs Band 1 (%)	The percentage of saturated observations from Level 1B in Band 1 in the swath	0.0 - 100.0
Saturated EV Obs Band 2 (%)	The percentage of Saturated observations from Level 1B in Band 2 in the swath	0.0 - 100.0
Saturated EV Obs Band 4 (%)	The percentage of saturated observations from Level 1B in Band 4 in the swath	0.0 - 100.0
Saturated EV Obs Band	The percentage of	0.0 - 100.0

6 (%)	saturated observations from Level 1B in Band 6 in the swath	

Ice_Surface_Temperature

Ice surface temperature (IST) calculated by the split-window technique (see Algorithm Description section) is stored in this SDS. The IST is given in degrees Kelvin and is stored as calibrated data. To retrieve the IST the data must be descaled to degrees Kelvin using the calibration attributes:

$$IST (K) = scale\_factor * (calibrated\ data - add\_offset)$$

The valid range for IST is 210.00 – 313.00 K or 21000 – 31300 in calibrated form. Other features such as land and clouds are coded with integer values ≤ 5000. Values ≤ 5000 are not valid IST values but represent the occurrence of land, clouds or other features or conditions in the swath. The local attributes stored with the SDS are listed in Table 5. Coefficients used in the IST equation are given in Table 3.

Table 5. Local Attributes for the *Ice_Surface_Temperature* SDS.

Attribute Name	Definition	Value
long_name	Long Name of the SDS	Ice Surface Temperature by splitwindow method
units	SI units of the data	Degree_Kelvin
format	Data type format	F3.2
coordsys	Coordinate system for the data	Cartesian
valid_range	Max and min values of IST	21000 31300
_FillValue	Used to fill gaps in the swath	65535
scale_factor	Scale factor of calibrated data	0.010000
scale_factor_err	Scale factor error of calibrated data	0.000000
add_offset	Offset of calibrated data	0.000000
add_offset_err	Offset error of calibrated data	0.000000
calibrated_nt	Data type of calibrated data	5
Key	Key to meaning of data in the SDS	0.0=missing data 1.0=no decision 11.0=night 25.0=land 37.0=inland water 39.0=ocean 50.0=cloud 243.0-273.0 expected IST range 655.35=fill
Valid EV Obs Band 31 (%)	The percentage of valid observations from Level 1B	0.0-100.0

	in band 31 in the swath.	
Valid EV Obs Band 32 (%)	The percentage of valid observations from Level 1B in band 32 in the swath.	0.0-100.0
Saturated EV Obs Band 31 (%)	The percentage of saturated observations from Level 1B in band 31 in the swath.	0.0-100.0
Saturated EV Obs Band 32 (%)	The percentage of saturated observations from Level 1B in band 32 in the swath.	0.0-100.0

Sea_Ice_by_Reflectance_Pixel_QA

The quality assessment data provides an indication of the quality of the sea ice by reflectance algorithm output. Data for a pixel are determined to be of good quality, other quality or may be set to a thematic value for certain conditions. Unless the input data is unusable or missing the data quality will usually be set to good. Local attributes are listed in Table 6.

Table 6. Local Attributes with the *Sea_Ice_by_Reflectance_Pixel_QA*

Attribute name	Definition	Value
long_name	Long Name of the SDS	Sea ice by reflective characteristics spatial QA
units	SI units of the data	none
format	Data type	I3
coordsys	Coordinate system to use for the data	Cartesian
valid_range	Max and min values for QA	0-254
_FillValue	Used to fill gaps in the swath	255
Key	Key to meaning of data in the SDS	0=good quality 1=other quality 252=Antarctica mask 253=land mask 254=ocean mask 255=fill

Ice_Surface_Temperature_Pixel_QA

The quality assessment data provides an indication of the quality of the output data from the IST algorithm. Data for a pixel are determined to be of good quality, other quality or may be set to a thematic value for certain conditions. MODIS bands 31 and 32 are checked to determine the quality of the IST. Unless the input data is unusable or missing the data quality will usually be set to good. Local attributes are listed in Table 7.

Table 7. Local Attributes with *Ice_Surface_Temperature_Pixel_QA*

Attribute name	Definition	Value
long_name	Long Name of the SDS	Ice surface temperature pixel QA
units	SI units of the data	none
format	Data type	I3
coordsys	Coordinate system to use for the data	Cartesian
valid_range	Max and min values for QA	0-254
_FillValue	Used to fill gaps in the swath	255
Key	Key to meaning of data in the SDS	0=good quality 1=other quality 252=Antarctica mask 253=land mask 254=ocean mask 255=fill

Latitude and Longitude

Coarse resolution (5 km) latitude and longitude data for geolocating the sea ice data are located in the *Latitude* and *Longitude* SDSs. The latitude and longitude data correspond to a center pixel of a 5 km by 5 km block of pixels in the sea ice SDSs. The mapping relationship of geolocation data to the sea ice data is specified in the global attribute StructMetadata.0. Mapping relationship was created by the HDF-EOS SDPTK toolkit during production. Geolocation data is mapped to the sea ice data with an offset = 2.5 and increment = 5. The first element (1,1) in the geolocation SDSs corresponds to element (5,5) in *Sea_Ice_by_Reflectance* SDS; the algorithm then increments by 10 in the cross-track or along-track direction to map geolocation data to the SDS. Local attributes are listed in Tables 8 and 9.

Table 8. Local attributes with *Latitude* SDS.

Attribute name	Definition	Value
long_name	Long Name of the SDS	Coarse 5 km resolution latitude
units	SI units of the data	degrees
valid_range	Max and min values for latitude	-90.00 90.00
_FillValue	Used to fill gaps in the swath	-999.000
Source	Source of data	MOD03 geolocation product data read from center pixel in 5 km box.

Table 9. Local attributes with *Longitude* SDS.

Attribute name	Definition	Value
long_name	Long Name of the SDS	Coarse 5 km resolution longitude
units	SI units of the data	degrees
valid_range	Max and min values of longitude	-180.00 180.00
_FillValue	Used to fill gaps in the swath	-999.000
Source	Source of data	MOD03geolocation product; data read from center pixel in 5 km box

Global Attributes

There are three ECS defined global attributes; CoreMetadata.0, ArchiveMetadata.0, and StructMetadata.0, written as very long character strings in parameter value language (PVL) format, and other product specific global attributes in the MOD29 product. Global attributes serve different purposes, such as search and order of products, mapping, and product version tracking.   A user wanting to learn more about HDF-EOS can find information about it at www.hdfgroup.org/hdfeos.html. A text dump of all the metadata and SDSs in a global MOD29 granule is given in Appendix A.

Sea Ice Extent Accuracy and Errors

Sea ice extent has been evaluated through visual comparison with MODIS reflectance imagery and comparative analysis with sea ice products and maps from other sources. Though no definitive quantitative comparisons have been reported, qualitative evaluations suggest that under clear sky conditions the sea ice extent maps are very accurate and show ice details at 1 km resolution. The extensive and frequent cloud cover in the Arctic is a limitation to the use of MODIS data for monitoring sea ice conditions.

Discrimination between clouds and sea ice is challenging. Clouds are masked using the MOD35_L2 cloud mask product so the accuracy and error of cloud discrimination in that algorithm is propagated into the MOD29 algorithm and product. The cloud conservative nature of the cloud mask leads to a bias of 'detecting' cloud over sea ice when the algorithm does not have a definitive result of clear sky over ocean surface. Detailed discussion of the cloud mask algorithm is not given here but the user should be aware that an artifact from the algorithm does appear in the sea ice product.   The cloud mask algorithm uses the Near-real-time Ice and Snow Extent (NISE) product, an ancillary data source, to initialize the sea ice background flag that is used to direct algorithm processing flow. The NISE resolution is 25 km, the cloud mask is 1 km resolution. That difference in NISE and MODIS resolution can be a cause of the cloud mask detecting sea ice as cloud in some situations which result in artifacts of straight line cloud edges sometimes with 90 degrees corners in the cloud mask, and sea ice detected as cloud. Those types of artifacts and error are seen in the low half of the subset images of MOD29 in Figure 1.

The C6 land/water mask is derived from the UMD 250m MODIS Water Mask data product (UMD Global Land Cover Facility http://glcf.umd.edu/data/watermask/description.shtml). Location of Arctic coastlines and rivers is greatly improved compared to the land/water mask used in C5. Users will probably notice the improved coastline mapping in all regions. Improved quality of the land water mask is seen through all product levels. The UMD 250 m Water Mask was converted to a 500 m seven class land/water mask for use in the production of MODIS products in C6. That was done to maintain continuity in the land/water mask used in all the land products in C5 to C6 but with greatly improved accuracy in location of water bodies resulting from the UMD 250 Water Mask (http://landweb.nascom.nasa.gov/QA_WWW/forPage/MODIS_C6_Water_Mask_v3.pdf) Geolocation accuracy remains constant from C5. There will be some 'wobble' in geolocation of land/water mask features but within expected range. Geolocation 'wobble' through the processing levels to level 3 may be observed by changes in location of a feature, like a coastline, from day to day in the MOD29P1 products.

IST Accuracy and Errors

In the product generation system the IST algorithm is applied to all ocean pixels, there is no prescreening for possible occurrence of sea ice. The IST is not a sea surface temperature algorithm and should not be used as one. The IST is only relevant to oceans and seas where sea ice occurs.

Under ideal conditions the IST accuracy is 1-3 K; see Hall et al. (2004), Hall et al., (in review) and Schuman et al., (2014) for discussion of the IST accuracy. IST was reported in the 1-3 K range by Scambos et al (2006). Ideal conditions for the split-window technique are clear sky with low amount of water vapor. Water vapor causes decline in accuracy of the IST. Cloud detection is also a factor affecting accuracy. Any clouds or partially cloudy conditions will decrease the accuracy of IST.

Discrimination between clouds and sea ice is challenging. Clouds are masked using the MOD35_L2 cloud mask product so the accuracy and error of cloud discrimination in that algorithm is propagated into the MOD29 algorithm and product. The cloud conservative nature of the cloud mask tends to result in clouds being detected in some situations of sea ice conditions. Detailed discussion of the cloud mask algorithm is not given here but the user should be aware that an artifact from the algorithm does appear in the sea ice product. The cloud mask algorithm uses the Near-real-time Ice and Snow Extent (NISE) product, an ancillary data source, to initialize the sea ice background flag that is used to direct algorithm processing flow. The NISE resolution is 25 km, the cloud mask is 1 km resolution. That difference in NISE and MODIS resolution can be a cause of the cloud mask detecting sea ice as cloud in some situations which result in artifacts of straight line cloud edges sometimes with 90 degrees corners in the cloud mask, and sea ice detected as cloud. Those types of artifacts and error are seen in the low half of the subset images of MOD29 in Figure 1.

The IST is calculated for night data, when MODIS in night mode only thermal data acquired, and the MOD35_L2 cloud mask is used for the night data. Cloud detection at night is very

challenging. Though the cloud mask is used it is considered very unreliable at night. Visual inspection of the IST product may be used to determine clear skies in some conditions, for example if sea ice features of flows or leads can be seen, then infer clear sky. Consider the IST night product as a research product.

The C6 land/water mask is derived from the UMD 250m MODIS Water Mask data product (UMD Global Land Cover Facility http://glcf.umd.edu/data/watermask/description.shtml). Location of Arctic coastlines and rivers is greatly improved compared to the land/water mask used in C5. Users will probably notice the improved coastline mapping in all regions. Improved quality of the land water mask is seen through all product levels. The UMD 250 m Water Mask was converted to a 500 m seven class land/water mask for use in the production of MODIS products in C6. That was done to maintain continuity in the land/water mask used in all the land products in C5 to C6 but with greatly improved accuracy in location of water bodies resulting from the UMD 250 Water Mask (http://landweb.nascom.nasa.gov/QA_WWW/forPage/MODIS_C6_Water_Mask_v3.pdf). There will be some 'wobble' in geolocation of land/water mask features but within expected range. Geolocation 'wobble' through the processing levels to level 3 may be observed by changes in location of a feature, like a coastline, from day to day in the MOD29P1 products.

In the IST algorithm the MODIS scan angle range of 55 degrees is used in the IST calculation. Recent investigation of the IST equation using fixed MODIS scan angle of 55 degrees or using the MODIS sensor zenith angle, which includes surface curvature effect, has shown that using either geometry yields an accurate IST; ISTs are generally within 1K with either geometry. That investigation was done using the special IST on Greenland data set so that the calculated IST could be compared to ground station data. Evaluation of the sensor scan angle on IST calculation continues.

A listing of published literature in which the MOD29 products have been evaluated, compared or used in some way is maintained on our project website at http://modis-snow-ice.gsfc.nasa.gov/

MOD29PG*
The level-2-gridded (L2G) product is the result of mapping all the MOD29 swaths from a calendar day, day and night granules, to grid cells of the Lambert Azimuthal Equal-Area (polar grid) projection. Separate products are generated for day and night. MOD29PGD and MOD29PGN are the day and night products. The Lambert Azimuthal Equal-Area projection is divided into Northern and Southern hemisphere polar grids and each grid is divided into tiles. The grids are compatible with the NSIDC EASE-Grid. Each grid contains 313 tiles with each tile covering approximately 10 x 10 degrees. References relevant to the EASE-Grid Lambert Azimuthal Equal-Area projection can be found in the related documents section of this guide.

The MOD29PG* products are necessary intermediate products used as input to the daily gridded sea ice products MOD29P1D and MOD29P1N. The MOD29PG* products are not archived at NSIDC.

MOD29P1D

This daily gridded level-3 sea ice product is the result of selecting an observation from the multiple observations mapped to a cell of the MOD29GP product as the "best" observation of the day. The daily sea ice product is a tile of data gridded in the Lambert Azimuthal Equal Area map projection. Spatial resolution is approximately 1 km; tiles are grid of 951 x 951 cells. There are two grids, one for the Northern Hemisphere and one for the Southern Hemisphere. Tile coordinate system is different for the grids. See modis-land.gsfc.nasa.gov/MODLAND_grid.html for a description of the grids. Sea ice extent and IST from a MOD29P1D product are shown in Figure 2.
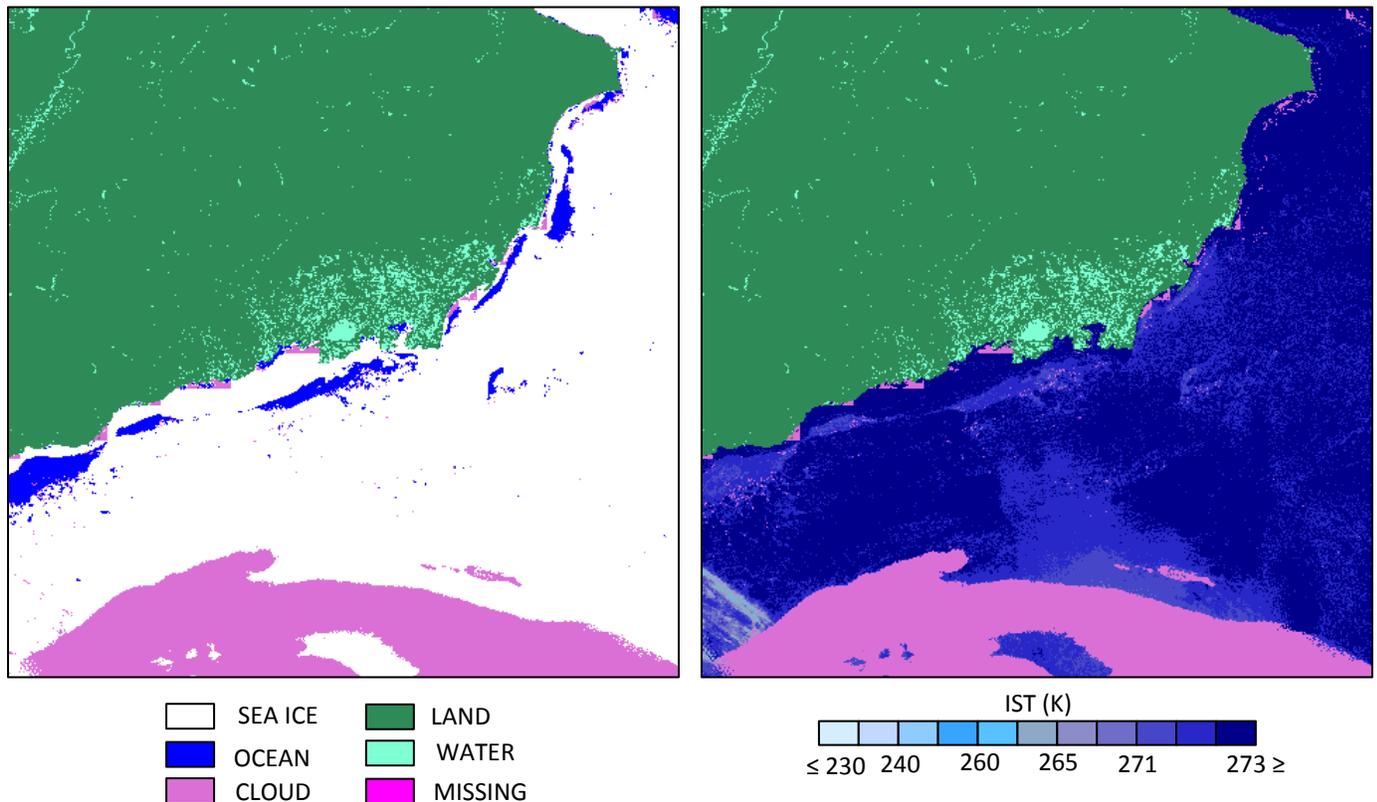

Figure 2.
Sea ice extent (left) and IST (right) from MOD29P1D.A200214.h08v07.006.2015054055253.hdf daily tiled product covering north coast of AK Lisburne Peninsula upper right corner, and Chukchi Sea. This region is covered in the MOD29 swath product shown in Figure 1.

Algorithm Description

From the many observations acquired during a day from multiple swaths covering a location a single observation is selected as the "best" observation of the day from the MOD29PGD

intermediate product. A scoring algorithm is used to select the "best" observation of the day based on solar elevation, observation coverage in a grid cell and distance from nadir. The objective of the algorithm is to select observations that were acquired near local noon time, had a large amount of coverage in a grid cell and that were near nadir of a swath. The input data are read from the L2G products listed in Table 10.   A weighting is given to these parameters in the algorithm. The form of the scoring algorithm is,
Score = (0.5 * solar elevation) + (0.3 * observation coverage) + (0.2 * distance from nadir)

All observations for a day are scored and the one with the highest score is selected as the observation for the day. This algorithm is applied to sea ice by reflectance and IST, so that the same pixel observation is selected. The corresponding QA data is also selected and output.

In situations where the day and night terminator lies in a tile, the IST is mapped on both sides of the terminator thus there may be regions where IST is mapped without corresponding sea ice by reflectance data in daytime granules.

Table 10. MODIS data product inputs to the MODIS daily sea ice algorithm.

ESDT	Long Name	Data Used
MOD29PGD	MODIS/Terra Sea Ice Extent Daily L2G Global 1km EASE-Grid Day	Sea ice IST and QA
MODMGPGD	MODIS/Terra Geolocation Angles Daily L2G Global 1km EASE-Grid Day	Solar and sensor geometry
MODPTPGD	MODIS/Terra Observation Pointers Daily L2G Global 1km Polar Grid Day	Number of observations coverage observation swath and location

Quality Assessment

QA data corresponding to the sea ice cover and IST observation selected for the daily gridded map are also selected and mapped into the *Sea_Ice_by_Reflectance_Spatial_QA* and *Ice_Surface_Temperature_Spatial_QA* SDSs. No quality assessment is done in this algorithm. All QA is inherited from the MOD29 product.

Scientific Data Sets

Sea_Ice_By_Reflectance
The sea ice extent map is the result of selecting the 'best' observation of all the swath level observations mapped into a grid cell for the day. The sea ice extent map is a binary map of sea ice or open ocean and includes, land, cloud and other features. A color-coded image of a sea ice extent map is shown in Figure 2. Local attributes are listed in Table 11.

Table 11. Local attributes with the *Sea_Ice_by_Reflectance* SDS

Attribute name	Definition	Value
long_name	Long Name of the SDS	Sea ice by reflectance for daily tile
units	SI units of the data	none
format	Data type	I3
coordsys	Coordinate system to use for the data	Cartesian
valid_range	Max and min values of sea ice extent	0-254
_FillValue	Used to fill gaps in the swath	255
Key	Key to meaning of data in the SDS	0=missing data 1=no decision 11=night 25=land 37=inland water 39=ocean 50=cloud 200=sea ice 253=land mask 254=ocean mask 255=fill

Ice_Surface_Temperature

The IST map is the result of selecting the 'best' observation of all the swath level observations mapped into a grid cell for the day. The IST and other features e.g. land, cloud or other features.   A color-coded image of IST map is shown in Figure 2. Local attributes are listed in Table 12.

The IST data are stored in HDF calibrated form so must be converted using the calibration data in the local attributes.

IST (K) = scale_factor * (calibrated data – add_offset).

Table 12 Local attributes for *Ice_Surface_Temperature*

Attribute Name	Definition	Value
long_name	Long Name of the SDS	Ice Surface Temperature for daily tile
units	SI units of the data	Degree_Kelvin
format	Data type and format	F4.1
coordsys	Coordinate system to use for the data	Cartesian
valid_range	Max and min values of IST	21000 31300
_FillValue	Used to fill gaps in the swath	7
scale_factor	Scale factor of calibrated data	0.010000

scale_factor_err	Scale factor error of calibrated data	0.000000
add_offset	Offset of calibrated data	0.000000
add_offset_err	Offset error of calibrated data	0.000000
calibrated_nt	Data type of calibrated data	5
Key	Key to meaning of data in the SDS	0.0=missing data 1.0=no decision 11.0=night 25.0=land 37.0=inland water 39.0=open ocean 50.0=cloud 243.0-273.0 expected IST range 655.35=fill

Sea_Ice_by_Reflectance_Spatial_QA

This is the QA data corresponding to the observation selected as 'best' observation of the day for sea ice extent. Local attributes are listed in Table 13.

Table 13. Local attributes for the *Sea_Ice_by_Reflectance_Spatial_QA* SDS

Attribute name	Definition	Value
long_name	Long Name of the SDS	Sea ice by reflectance for daily tile
units	SI units of the data	none
format	Data type	I3
coordsys	Coordinate system to use for the data	Cartesian
valid_range	Max and min values of QA	0-254
_FillValue	Used to fill gaps in the swath	255
Key	Key to meaning of data in the SDS	0=good quality, 1=other quality, 253=land mask, 254=ocean mask, 255=fill

Ice_Surface_Temperature_Spatial_QA

This is the QA data corresponding to the observation selected as 'best' observation of the day for IST. Local attributes are listed in Table 14.

Table 14. Local Attributes with *Ice_Surface_Temperature_Spatial _QA* SDS.

Attribute name	Definition	Value
long_name	Long Name of the SDS	Ice_Surface_Temperature_Spatial_QA
units	SI units of the data	none
format	Data type	I3

coordsys	Coordinate system to use for the data	Cartesian
valid_range	Max and min values for QA	0-254
_FillValue	Used to fill gaps in the swath	255
Key	Key to meaning of data in the SDS	0=good quality, 1=other quality, 253=land mask, 254=ocean mask, 255=fill

Global Attributes

There are three are ECS defined global attributes; CoreMetadata.0, ArchiveMetadata.0, and StructMetadata.0, written as very long character strings in parameter value language (PVL) format, and other product specific global attributes in the MOD29P1D product. Global attributes serve different purposes, such as search and order of products, mapping, and product version tracking.   A user wanting to learn more about HDF-EOS can find information about it at www.hdfgroup.org/hdfeos.html. A Text dump of the global attributes from a MOD29P1D granule is given in Appendix B.

Sea Ice Extent and IST Accuracy and Errors

Accuracy and errors are inherited from the MOD29 product. Some error in geolocation may be associated with reprojection from latitude and longitude coordinates to the EASE-Grid Lambert Azimuthal equal area projection of the product. Geolocation error may be notable along coastlines which may appear to shift between cells of the grid from day to day.

Artifacts of the cloud mask usage of the NISE product to set the ice background flag in processing may be apparent as a cloud area having a straight line edge and possibly 90 degree corners and detecting sea ice as cloud in the MOD29 product (cf. MOD29 Accuracy and Error discussion above).

IST is mapped in the region of darkness 85° – 90° solar zenith angle where sea ice extent is not so in the terminator region the sea ice extent and IST maps will have different coverage. In this day product the IST from a swath in which MODIS is in night mode is not mapped, night IST is in the MOD29P1N product.

Over the polar regions the number of MODIS acquisitions in daylight or night mode, only thermal data acquired in night mode, varies with the seasons. During the boreal summer the Arctic region can be imaged many times, perhaps up to fourteen swaths, during a 24 hour period. A user should carefully consider which level of the sea ice products will best meet their research or application needs. The objective of the daily sea ice and IST algorithm is to report the 'best' observation of a day based primarily on time of overpass and viewing angle, the 'best' being near local solar noon and close to nadir. That techniques works to map swath inputs as contiguous spatially and temporally in a tile, with mixing of swath observations occurring along edges of swath overlap. Swath seams are seen as a weave pattern in the data when there is a

difference in cloud cover or surface features between adjacent swaths. Only a single 'best' sea ice extent and corresponding IST observation are mapped in the data product.

This daily sea ice product may not be the best for a user because it lacks all the observations that a user could access if the swath products were used instead of this single daily 'best' observation. Sea ice moves, clouds move, the satellite passes over about every 99 minutes. These are all factors for a user to consider when deciding on which sea ice product to use, and interpreting the daily gridded products.

MOD29P1N

This product contains only the IST data acquired during nighttime. Two SDSs are stored in the product. The nighttime sea ice product is a tile of data gridded in the EASE-Grid Lambert Azimuthal Equal Area map projection. Spatial resolution is approximately 1 km. Tile dimensions are 951 x 951 grid cells.

Algorithm Description

The algorithm selects observations that were acquired nearest nadir and with the largest amount of coverage in a grid cell. A weighting is given to these parameters in the algorithm. The form of the scoring algorithm is:

Score = (0.3 * observation coverage) + (0.2 * distance from nadir)

These data are read from the L2G products of sea ice (MOD29PGN) and pointer (MODPTPGN). All input observations are scored and the one with the highest score is selected as the observation for the night.

Table 15. ESDT inputs to the MOD29P1N algorithm.

ESDT	Long Name	Data Used
MOD29PGN	MODIS/Terra Sea Ice Extent Daily L2G Global 1km EASE-Grid Day	IST and QA
MODPTPGN	MODIS/Terra Observation Pointers Daily L2G Global 1km Polar Grid Day	Number of observations coverage observation swath and location

Quality Assessment

QA data is inherited from the MOD29 IST input. No quality assessment is done in the algorithm.

Scientific Data Sets

Ice_Surface_Temperature

The IST observation selected by the algorithm is stored in this SDS. Data are stored as scaled integers and must be de-scaled to degrees Kelvin using the Calibration local attribute.

IST (K) = scale_factor * (calibrated data – add_offset)

Local attributes are listed in Table 16.

Table 16. Local attributes with the *Ice_Surface_Tempertature* SDS.

Attribute Name	Definition	Value
long_name	Long Name of the SDS	Ice_Surface_Temperature
units	SI units of the data	degree_Kelvin
format	Data type and format	F4.1
coordsys	Coordinate system to use for the data	Cartesian
valid_range	Max and min IST values	21000, 31300
_FillValue	Used to fill gaps in the swath	7
scale_factor	Scale factor of calibrated data	0.010000
scale_factor_err	Scale factor error of calibrated data	0.000000
add_offset	Offset of calibrated data	0.000000
add_offset_err	Offset error of calibrated data	0.000000
calibrated_nt	Data type of calibrated data	23
Key	Key to meaning of data in the SDS	0.0=missing data 1.0=no decision 11.0=night 25.0=land 37.0=inland water 39.0=open ocean 50.0=cloud 243.0-273.0 expected IST range 655.35=fill

Ice_Surface_Temperature_Spatial_QA
QA data corresponding to the selected IST observation are mapped into the Ice_Surface_Temperature_Spatial_QA SDS. Local attributes are listed in Table 17.

Table 17. Local Attributes with *Ice_Surface_Temperature_Spatial _QA* SDS.

Attribute name	Definition	Value
long_name	Long Name of the SDS	Ice_Surface_Temperature_Spatial_QA
units	SI units of the data	none
format	Data type	I3
coordsys	Coordinate system to use for the data	Cartesian
valid_range	Max and min values of QA	0-254
_FillValue	Used to fill gaps in the swath	255

Key	Key to meaning of data in the SDS	0=good quality, 1=other quality, 253=land mask, 254=ocean mask, 255=fill

Global Attributes

There are three ECS defined global attributes, CoreMetadata.0, ArchiveMetadata.0, and StructMetadata.0, written as very long character strings in parameter value language (PVL) format, and other product specific global attributes in the MOD29P1D product. Global attributes serve different purposes, such as search and order of products, mapping, and product version tracking.   A user wanting to learn more about HDF-EOS can find information about it at www.hdfgroup.org/hdfeos.html. Text of the global attributes from a MOD29P1N granule is given in Appendix C.

Night time IST Accuracy and Errors

Uncertainty in cloud detection at night is probably the greatest problem to contend with in the nighttime IST product and algorithm. Cloud contamination of IST retrieval can infuse substantial error in IST compared to clear sky conditions.

In the polar regions when there is 24 hours of daylight there is no IST data in the product, all the data is mapped into the MOD29P1D product. The extent of IST coverage in a tile expands and contracts with the length of daylight over polar regions. Perusing the MOD29P1N browse images when searching for data is a way to see the extent and change in coverage.

MOD29E1D

The global daily Level-3 sea ice product has sea ice extent and ice surface temperature (IST) in the EASE-Grid polar projections at approximately 4 km spatial resolution, Figure 3. Polar projections for north and south poles are in the data product; data arrays have dimensions of 4501 x 4501 grid cells. The product contains four SDSs with local attributes and global attributes.

	SEA ICE		LAND
	OCEAN		WATER
	CLOUD		MISSING

IST (K)

≤ 230   240   260   265   271   273 ≥
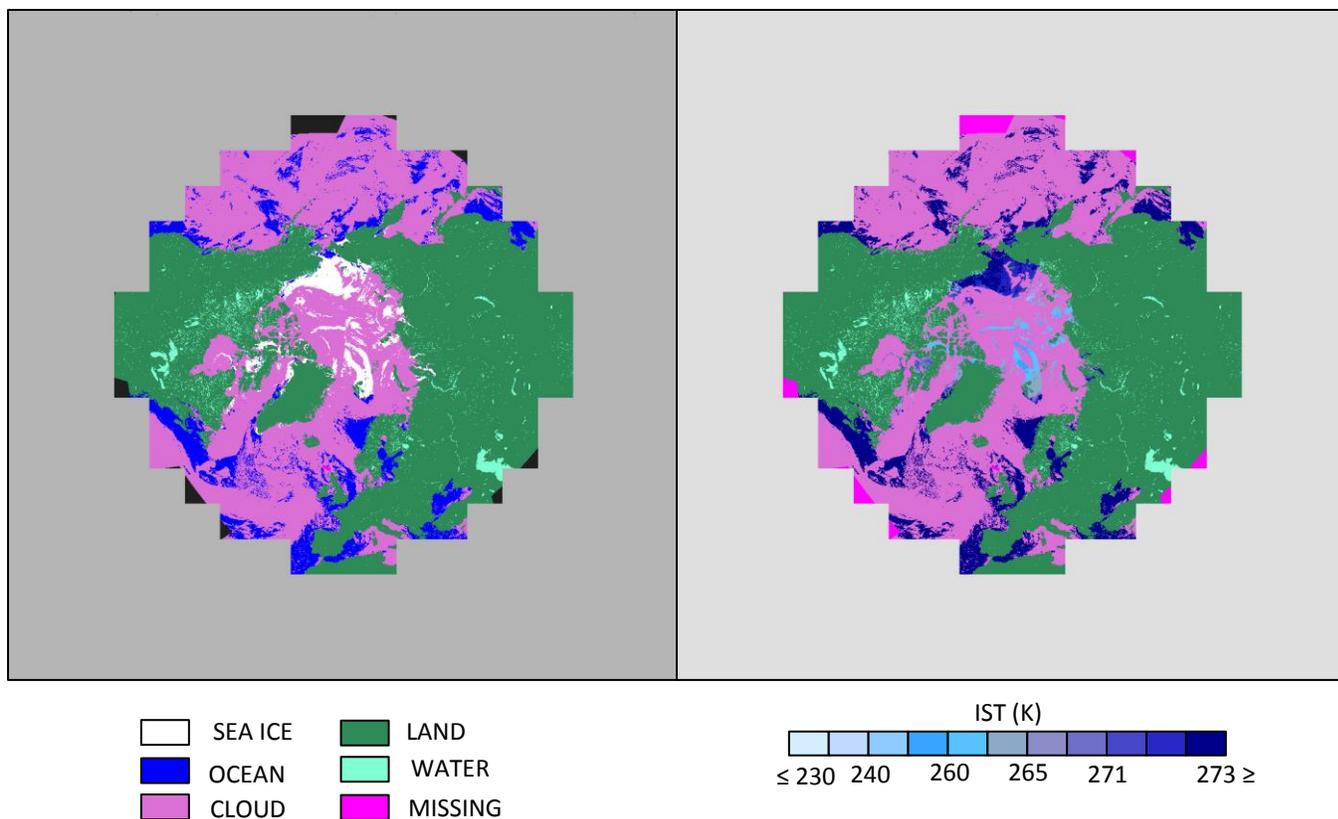
Figure 3. Daily hemispheric sea ice extent (left) and IST (right) both at 4 km resolution from MOD29E1D.A2002143.006.2015054060612.hdf.

Algorithm Description

Input to the daily global sea ice algorithm is the daily sea ice product MOD29P1D. There are nominally 121 input tiles for the Northern Hemisphere and 76 for the Southern Hemisphere. Input data at approximately 1 km resolution are mapped to an input polar grid of 1 km resolution then that grid is mapped onto the output grid of approximately 4 km resolution. The output grid is based on the EASE-Grid projection. The gridded input observation nearest the center of an output grid cell is assigned as the output value for that grid cell. Approximately every fourth input grid cell is mapped into an output grid cell.

Quality Assessment

QA data has been omitted from this product because the purpose of the product is to give a general view of hemispheric sea ice by compositing subsampled MOD29P1D products. Reporting of quality assessment data will probably change in a future version and be based on further evaluation and validation of the product.

Scientific Data Sets

Sea_Ice_by_Reflectance_NP and Sea_Ice_by_Reflectance_SP
Extent of sea ice determined by reflectance characteristics is mapped in this SDS.

The observation stored is the one that was mapped into the center of the output grid from the input grid of daily tiled sea ice products. Local attributes are listed in Table 18.

Table 18. Local attributes for the *Sea_Ice_by_Reflectance_NP* and *Sea_Ice_by_Reflectance_SP* SDSs

Attribute name	Definition	Value
long_name	Long Name of the SDS	Sea ice by reflectance 4 km global North Pole grid OR Sea ice by reflectance 4 km global South Pole grid
units	SI units of the data	none
coordsys	Coordinate system to use for the data	Cartesian
valid_range	Max and min values of sea ice	0-254
_FillValue	Used to fill gaps in the swath	255
Missing_value	For missing data	0
Key	Key to meaning of data in the SDS	0=missing data 1=no decision 11=night 25=land 37=inland water 39=ocean 50=cloud 200=sea ice 253=no input tile expected 254=nonproduction mask

Ice_Surface_Temperature_NP and Ice_Surface_Temperature_NP

Ice surface temperature (IST) in Kelvin is mapped in this SDS. The observation stored is the one that was mapped into the center of the output grid from the input grid of the daily tiled sea ice products. IST data are stored as scaled integers and must be de-scaled to degrees Kelvin using local attributes:

IST (K) = scale_factor * (calibrated data – add_offset)

Valid range of IST is 210.00 – 313.20K. Local attributes are listed in Table 19.

Table 19 Local attributes for the *Ice_Surface_Temperature_NP* and *Ice_Surface_Temperature_SP* SDSs.

Attribute Name	Definition	Value
long_name	Long Name of the SDS	Estimated sea ice surface temperature 4 km North Pole grid OR Estimated sea ice surface temperature 4 km South Pole grid
units	SI units of the data	degree_Kelvin
format	Data type and format	F4.1
coordsys	Coordinate system to use	Cartesian

	for the data	
valid_range	Max and min IST values	21000, 31300
_FillValue	Used to fill gaps in the swath	7
Missing_value	Used for missing data	0
scale_factor	Scale factor of calibrated data	0.010000
scale_factor_err	Scale factor error of calibrated data	0.000000
add_offset	Offset of calibrated data	0.000000
add_offset_err	Offset error of calibrated data	0.000000
calibrated_nt	Data type of calibrated data	23
Key	Key to meaning of data in the SDS	0.0=missing data 1.0=no decision 5.0 non-production mask 7.0 tile fill 8.0 no input tile expected 11.0=night 25.0=land 37.0=inland water 39.0=open ocean 50.0=cloud 243.0-273.0 expected IST range 655.35=fill

Sea Ice and IST Evaluation and Errors

The purpose of the global product is to give a daily synoptic map of sea ice extent and IST by re-gridding of 1 km data to 4 km resolution. Accuracy and error are inherited from the input data product sequence.

Continuity of features of sea ice and IST may sometimes be lacking, especially in the polar summer season, because pixels come from different swaths, separated in time during which sea ice and/or clouds could have moved.

References

Note: A partial listing of publications in which the MODIS sea ice products have been used in some way can be found at the MODIS Snow/Ice Global Mapping Project http://modis-snow-ice.gsfc.nasa.gov

Baum, B.A., Menzel, P.W., Frey, R.A., Tobin, D.C. Holz, R.E. Ackerman, S.A. Heidinger, A.K., Yang, P. 2012. MODIS cloud-top property refinements for Collection 6. Journal of Applied Meteorology and Climatology, 51(1145-1163), DOI:10.1175/JAMC-D-11-0203.1

Hall, D.K., J. Key, K.A. Casey, G.A. Riggs and D. Cavalieri, 2004: "Sea ice surface temperature product from the Moderate Resolution Imaging Spectroradiometer (MODIS)," IEEE Transactions on Geoscience and Remote Sensing, 42:1076-1087.

Hall, D.K., A.B. Tait, G.A. Riggs, V.V. Salomonson, with contributions from J.Y.L. Chien, A.G. Klein, October 7, 1998: "Algorithm Theoretical Basis Document (ATBD) for the MODIS Snow-Lake Ice- and Sea Ice-Mapping Algorithms. Version 4.0"

Hall, D.K., S.V. Nghiem, I.G. Rigor and J.A. Miller., in review: Uncertainties of temperature measurements on snow-covered land and sea ice from in-situ and MODIS data during BROMEX, Journal of Applied Meteorology and Climatology.

Scambos, T.A., T.M. Haran and R. Massom, 2006: Validation of AVHRR and MODIS Ice Surface Temperature Products Using In Situ Radiometers, Annals of Glaciology, 44:345-351.

Shuman, C.A., D.K. Hall, N.E. DiGirolamo, T.K. Mefford, and M.J. Schnaubelt, 2014: Comparison of near-surface air temperatures and MODIS ice-surface temperatures at Summit, Greenland (2008-2013), Journal of Applied Meteorology and Climatology, 53(9):2171-2180.

Related Web Sites
EOS
Terra Website **http://terra.nasa.gov**
Aqua Website **http://aqua.nasa.gov**

MODIS
MODIS Snow/Ice Global Mapping Project **http://modis-snow-ice.gsfc.nasa.gov**
MODIS Project **http://modis.gsfc.nasa.gov**
MODIS Land Discipline **http://modis-land.gsfc.nasa.gov**
MODIS Land Quality Assessment **landweb.nascom.nasa.gov/cgi-bin/QA_WWW/newPage.cgi**
MODIS Land Global Browse Images **landweb.nascom.nasa.gov/cgi-bin/browse/browseMODIS.cgi**
MODIS Characterization Support Team **http://mcst.gsfc.nasa.gov**
MODIS Atmosphere Discipline **http://modis-atmos.gsfc.nasa.gov**

DAAC
National Snow and Ice Data Center **http://nsidc.org/daac**

HDF-EOS Information and Tools
EOSDIS **https://earthdata.nasa.gov**
HDF **http://www.hdfgroup.org**

NSIDC **http://nsidc.org/data/modis/tools.html**
Goddard Earth Sciences Data and Information Services Center **http://disc.sci.gsfc.nasa.gov/**

Earth Science
Earth Observatory **earthobservatory.nasa.gov/?eocn=topnav&eoci=logo**
Earth Right Now **www.nasa.gov/earthrightnow/#.VGz1JOLkfmE**
NASA's Earth Observing System Project Science Office **eospso.gsfc.nasa.gov**

Appendix A

The MOD29 product metadata tables are given in this appendix. CoreMetadata.0, ArchiveMetadata.0 and product specific metadata objects are global attributes containing information about product inputs and outputs. StructMetadata.0 attribute contains information about the swath geolocation and projection relevant to the granule.

New global attributes of *identifier_product_doi* and *identifier_product_doi_authority* may, in the future, be used to find information about the product.

Table A.1. Listing of the swath structure metadata in MOD29.

```
StructMetadata.0
GROUP=SwathStructure
      GROUP=SWATH_1
             SwathName="MOD_Swath_Sea_Ice"
             GROUP=Dimension
                    OBJECT=Dimension_1
                           DimensionName="Coarse_swath_lines_5km"
                           Size=406
                    END_OBJECT=Dimension_1
                    OBJECT=Dimension_2
                           DimensionName="Coarse_swath_pixels_5km"
                           Size=271
                    END_OBJECT=Dimension_2
                    OBJECT=Dimension_3
                           DimensionName="Along_swath_lines_1km"
                           Size=2030
                    END_OBJECT=Dimension_3
                    OBJECT=Dimension_4
                           DimensionName="Cross_swath_pixels_1km"
                           Size=1354
                    END_OBJECT=Dimension_4
             END_GROUP=Dimension
             GROUP=DimensionMap
                    OBJECT=DimensionMap_1
                           GeoDimension="Coarse_swath_pixels_5km"
                           DataDimension="Cross_swath_pixels_1km"
                           Offset=2
                           Increment=5
                    END_OBJECT=DimensionMap_1
                    OBJECT=DimensionMap_2
                           GeoDimension="Coarse_swath_lines_5km"
                           DataDimension="Along_swath_lines_1km"
                           Offset=2
                           Increment=5
```

```
                    END_OBJECT=DimensionMap_2
              END_GROUP=DimensionMap
              GROUP=IndexDimensionMap
              END_GROUP=IndexDimensionMap
              GROUP=GeoField
                    OBJECT=GeoField_1
                          GeoFieldName="Latitude"
                          DataType=DFNT_FLOAT32

      DimList=("Coarse_swath_lines_5km","Coarse_swath_pixels_5km")
                    END_OBJECT=GeoField_1
                    OBJECT=GeoField_2
                          GeoFieldName="Longitude"
                          DataType=DFNT_FLOAT32

      DimList=("Coarse_swath_lines_5km","Coarse_swath_pixels_5km")
                    END_OBJECT=GeoField_2
              END_GROUP=GeoField
              GROUP=DataField
                    OBJECT=DataField_1
                          DataFieldName="Sea_Ice_by_Reflectance"
                          DataType=DFNT_UINT8
                          DimList=("Along_swath_lines_1km","Cross_swath_pixels_1km")
                    END_OBJECT=DataField_1
                    OBJECT=DataField_2
                          DataFieldName="Sea_Ice_by_Reflectance_Pixel_QA"
                          DataType=DFNT_UINT8
                          DimList=("Along_swath_lines_1km","Cross_swath_pixels_1km")
                    END_OBJECT=DataField_2
                    OBJECT=DataField_3
                          DataFieldName="Ice_Surface_Temperature"
                          DataType=DFNT_UINT16
                          DimList=("Along_swath_lines_1km","Cross_swath_pixels_1km")
                    END_OBJECT=DataField_3
                    OBJECT=DataField_4
                          DataFieldName="Ice_Surface_Temperature_Pixel_QA"
                          DataType=DFNT_UINT8
                          DimList=("Along_swath_lines_1km","Cross_swath_pixels_1km")
                    END_OBJECT=DataField_4
              END_GROUP=DataField
              GROUP=MergedFields
              END_GROUP=MergedFields
        END_GROUP=SWATH_1
END_GROUP=SwathStructure
GROUP=GridStructure
END_GROUP=GridStructure
GROUP=PointStructure
END_GROUP=PointStructure
END
```

Table A.2. MOD29 CoreMetadata.0 objects.

Object Name	Sample Value	Comment
LocalGranuleID	"MOD29.A2002143.2330.006.2015054052706. "	Filename of product. Format is EDST.Ayyyyddd.hhmm.vvv.yyyyddddhhmmss.hdf. Time in UTC.
ProductionDateTime	" 2015-02-23T05:27:09.000Z"	Date and time the file was produced. Format is; yyyy-mm-ddThh:mm:ss.sssZ
DayNightFlag	"Day"	Day means entire swath in daylight. Both means that part of swath lies in darkness. Night means entire swath in darkness.
ReprocessingActual	"reprocessed"	Reprocessed means data has been processed before. Processed once means this is the first processing of the data.
LocalVersionID	"SCF V5.0.1"	Version of algorithm delivered from the SCF
ReprocessingPlanned	"further update is anticipated"	Expect that products will be reprocessed one or more times.
ScienceQualityFlag	"Not Investigated"	See ScienceQualityFlagExplanation for current information.
AutomaticQualityFLagExplanation	"No automatic quality assessment done in the PGE "	No automated QA checks made during execution of the algorithm.
AutomaticQualityFlag	"Passed"	Default setting because no automated QA checks are done.
SciencelQualityFlagExplanation	"See http://landweb.nascom.nasa.gov/cgi-bin/QA_WWW/qaFlagPage.cgi?sat=terra for the product Science Quality status."	URL where updated information on science QA should be posted.
QAPercentMissingData	0	Amount of L1B data missing from the swath.
QAPercentCloudCover	56	Amount of ocean in the swath obscured by clouds.
ParameterName	"Sea_Ice_by_Reflectance"	QA parameters given apply to the listed data fields.
ScienceQualityFlag	"Not Investigated"	See ScienceQualityFlagExplanation for current information.
AutomaticQualityFLagExplanation	"No automatic quality assessment done in the PGE "	No automated QA checks made during execution of the algorithm.
AutomaticQualityFlag	"Passed"	Default setting because no automated QA checks are done.
SciencelQualityFlagExplanation	"See http://landweb.nascom.nasa.gov/cgi-	URL where updated information on science QA should be posted.

	bin/QA_WWW/qaFlagPage.cgi?sat=terra for the product Science Quality status."	
QAPercentMissingData	0	Amount of L1B data missing from the swath.
QAPercentCloudCover	56	Amount of land in the swath obscured by clouds.
ParameterName	"Ice_Surface_Temperature"	
EquatorCrossingDate	"2002-05-23"	Orbital parameter. Format;yyyy-mm-dd
EquatorCrossingTime	"23:53:44.033160"	Orbital parameter. Format; hh:mm:ss:ssssss
OrbitNumber	12926	Orbital parameter.
EquatorCrossingLongitude	159.373272476172	Orbital parameter. Decimal degrees format.
VersionID	6	Indicates the EOSDIS Collection
ShortName	"MOD29"	ESDT name of product
GringPointLongitude	(125.49597686, -115.246974959087, -154.782060627553, 155.999758646251)	These latitude and longitude pairs of points when connected in a clockwise series form a polygon of the swath coverage. Always represents the outer ring of coverage.
GringPointLatitude	(85.6123825594459, 70.9874250726339, 61.1984096590387, 68.0946492081388)	
GringPointSequenceNo	(1,2,3,4)	
ExclusionGRingFlag	"N"	
RangeEndingDate	" 2002-05-23"	Beginning and ending times of the first and last scan line in the swath. Formats are; yyyy-mm-dd hh:mm:ss.ssssss
RangeEndingTime	" 23:35:00.000000"	
RangeBeginningDate	" 2002-05-23"	
RangeBeginningTime	" 23:30:00.000000"	
PGEVersion	"6.0.4"	Version of production generation executable.
InputPointer	("MOD021KM.A2002143.2330.006.2014232003420.hdf", "MOD35_L2.A2002143.2330.006.2014312092819.hdf", "MOD03.A2002143.2330.006.2012254203722.hdf")	Names of MODIS data input files.
AncillaryInputPointer	"MOD03.A2002143.2330.006.2012254203722.hdf"	Name of the geolocation file.
AncillaryInputType	"Geolocation"	Type of ancillary data referenced by pointer.
AssociatedSensorShortName	"MODIS"	Sensor name.
AssociatedPlatformShortName	"Terra"	Platform name.
AssociatedInstrumentShortName	"MODIS"	Instrument and sensor name are the same.

Product Specific Attributes (PSA)		
QAPERCENTGOODQUALITY	100	Summary quality of data range checks done in the algorithm.
QAPERCENTOTHERQUALITY	0	
GRANULENUMBER	284	Unique granule identifier
SEAICEPERCENT	40	Summary percentage of sea ice detected (0 – 100).
identifier_product_doi	"10.5067/MODIS/MOD29.006"	Sources of additional information on the product – not currently enabled.
identifier_product_doi_authority	"http://dx.doi.org"	

Table A.3. MOD29 ArchiveMetadta.0 objects.

Object Name	Typical Value	Comment
AlgorithmPackageAcceptanceDate	"05-2005"	0Algorithm version information. Format is mm-yyyy.
AlgorithmPackageMaturityCode	"Normal"	
AlgorithmPackageName	"MOD_PR29"	
AlgorithmPackageVersion	"5"	
InstrumentName	"Moderate-Resolution Imaging SpectroRadiometer"	Long name of MODIS
Processing Center	"MODAPS"	MODIS Adaptive Processing System
ProcessingDateTime	" 2015-02-23T05:27:09.000Z"	Date of processing. Format is; yyyy-mmddThh:mm:ss.sssZ
SPSOParameters	"none"	Not used.
LongName	"MODIS/Terra Sea Ice Extent 5-Min L2 Swath 1km"	Descriptive name of the product. Maybe displayed as the product name in the EOS data search tools.
LocalInputGranuleID	("MOD021KM.A2002143.2330.006.2014232003420.hdf", "MOD35_L2.A2002143.2330.006.2014312092819.hdf", "MOD03.A2002143.2330.006.2012254203722.hdf")	Names of MODIS input files.
WestBoundingCoordinate	129.094778194461	Eastern, western, northern, and
NorthBoundingCoordinate	86.5772040075391	

		southern most points of the swath. Format is decimal degrees.
EastBoundingCoordinate	-115.248915123567	southern most points of the
SouthBoundingCoordinate	61.4613111346721	swath. Format is decimal degrees.
Processing Environment	"Linux minion5659 2.6.18-400.1.1.el5 #1 SMP Thu Dec 18 00:59:53 EST 2014 x86_64 x86_64 x86_64 GNU/Linux"	Location of processing.
DESCRRevison	"6.0"	Descriptor file associated with the PGE.

Table A.4 MOD29 product specific global attributes.

Attribute Name	Typical Value	Comment
HDFEOSVersion	HDFEOS_V2.9	Version of HDF_EOS.
L1BCalibrationQuality	marginal	Quality indicators of MOD02HKMdata.
L1BMissionPhase	EXECUTION	
L1BNadirPointing	Y	
L1BVersionID	2002-05-23	Version of the L1B processing algorithm.
L1BAutoQA_EV_1KM_RefsB	Suspect	Result of generalized quality analysis of L1B data
SCF Algorithm Version	"$Id:MOD_PR29_AA…"	Internal SCF version of the code modules, obsolete.
identifier_product_doi	10.5067/MODIS/MOD29.006	Sources of additional information on the product – not currently enabled.
identifier_product_doi_authority	http://dx.doi.org	

Appendix B

The MOD29P1D and MOD29P1N product metadata tables are given in this appendix. CoreMetadata.0, ArchiveMetadata.0 and product specific metadata objects are global attributes containing information about product inputs and outputs. StructMetadata.0 attribute contains information about the grid and projection relevant to the tile.

Only a single listing is given for the day product, the night product has the same metadata except that there is no sea ice by reflectance data included.

New global attributes of *identifier_product_doi* and *identifier_product_doi_authority* may, in the future, be used to find information about the product.

Table B.1. Listing of the grid structure metadata in MOD29P1D.

```
StructMetadata.0   DFNT_CHAR8
GROUP=SwathStructure
END_GROUP=SwathStructure
GROUP=GridStructure
        GROUP=GRID_1
                GridName="MOD_Grid_Seaice_1km"
                XDim=951
                YDim=951
                UpperLeftPointMtrs=(-1430352.976500,2383921.627500)
                LowerRightMtrs=(-476784.325500,1430352.976500)
                Projection=GCTP_LAMAZ
                ProjParams=(6371228,0,0,0,0,90000000,0,0,0,0,0,0,0)
                SphereCode=-1
                GridOrigin=HDFE_GD_UL
                GROUP=Dimension
                END_GROUP=Dimension
                GROUP=DataField
                        OBJECT=DataField_1
                                DataFieldName="Sea_Ice_by_Reflectance"
                                DataType=DFNT_UINT8
                                DimList=("YDim","XDim")
                                CompressionType=HDFE_COMP_DEFLATE
                                DeflateLevel=9
                        END_OBJECT=DataField_1
                        OBJECT=DataField_2
                                DataFieldName="Sea_Ice_by_Reflectance_Spatial_QA"
                                DataType=DFNT_UINT8
                                DimList=("YDim","XDim")
                                CompressionType=HDFE_COMP_DEFLATE
                                DeflateLevel=9
                        END_OBJECT=DataField_2
                        OBJECT=DataField_3
                                DataFieldName="Ice_Surface_Temperature"
                                DataType=DFNT_UINT16
                                DimList=("YDim","XDim")
                                CompressionType=HDFE_COMP_DEFLATE
                                DeflateLevel=9
                        END_OBJECT=DataField_3
                        OBJECT=DataField_4
                                DataFieldName="Ice_Surface_Temperature_Spatial_QA"
                                DataType=DFNT_UINT8
                                DimList=("YDim","XDim")
                                CompressionType=HDFE_COMP_DEFLATE
                                DeflateLevel=9
                        END_OBJECT=DataField_4
```

```
        END_GROUP=DataField
        GROUP=MergedFields
        END_GROUP=MergedFields
     END_GROUP=GRID_1
END_GROUP=GridStructure
GROUP=PointStructure
END_GROUP=PointStructure
END
```

Table B.2. MOD29P1D CoreMetadata.0 objects.

Object Name	Sample Value	Comment
LocalGranuleID	"MOD29P1D.A2002143.h08v07.006.2015054055253.hdf"	Filename of product. Format is EDST.Ayyyyddd.hhmm.vvv.yyyydddhhmmss.hdf. Time in UTC.
ProductionDateTime	"2015-02-23T05:52:57.000Z"	Date and time the file was produced. Format is; yyyy-mm-ddThh:mm:ss.sssZ
DayNightFlag	"Day"	Day means entire swath in daylight. Both means that part of swath lies in darkness. Night means entire swath in darkness.
ReprocessingActual	"reprocessed"	Reprocessed means data has been processed before. Processed once means this is the first processing of the data.
LocalVersionID	"SCF 5.0.0"	Version of algorithm delivered from the SCF
ReprocessingPlanned	"further update is anticipated"	Expect that products will be reprocessed one or more times.
ScienceQualityFlag	"Not Investigated"	See ScienceQualityFlagExplanation for current information.
AutomaticQualityFLagExplanation	"No automatic quality assessment done in the PGE "	No automated QA checks made during execution of the algorithm.
AutomaticQualityFlag	"Passed"	Default setting because no automated QA checks are done.
SciencelQualityFlagExplanation	"See http://landweb.nascom.nasa.gov/cgi-bin/QA_WWW/qaFlagPage.cgi?sat=terra for the product Science Quality status."	URL where updated information on science QA should be posted.
QAPercentMissingData	0	Amount of L1B data missing from the tile.
QAPercentCloudCover	11	Amount of ocean in the tile obscured by clouds.
ParameterName	"Ice_Surface_Temperature"	QA parameters given apply to the

		listed data fields.	
ScienceQualityFlag	"Not Investigated"	See ScienceQualityFlagExplanation for current information.	
AutomaticQualityFLag Explanation	"No automatic quality assessment done in the PGE "	No automated QA checks made during execution of the algorithm.	
AutomaticQualityFlag	"Passed"	Default setting because no automated QA checks are done.	
SciencelQualityFlagEx planation	"See http://landweb.nascom.nasa.g ov/cgi- bin/QA_WWW/qaFlagPage.c gi?sat=terra for the product Science Quality status."	URL where updated information on science QA should be posted.	
QAPercentMissingDat a	2	Amount of L1B data missing from the swath.	
QAPercentCloudCove r	11	Amount of land in the swath obscured by clouds.	
ParameterName	"Sea_Ice_by_Reflectance"		
EquatorCrossingDate	"2002-05-23"	Orbital parameter. Format;yyyy-mm-dd	These are reported for all orbit tracks mapped into a tile, there may be 1 to many orbits.
EquatorCrossingTime	"23:53:44.033160"	Orbital parameter. Format; hh:mm:ss:ssssss	
OrbitNumber	12926	Orbital parameter.	
EquatorCrossingLongi tude	159.373272476172	Orbital parameter. Decimal degrees format.	
VersionID	6	Indicates the EOSDIS Collection	
ShortName	"MOD29P1D"	ESDT name of product	
InputPointer	("MOD29PGD.A2002143.h08 v07.006.2015054055246.hdf" , "MODPTPGD.A2002143.h08 v07.006.2015054055057.hdf" , "MODMGPGD.A2002143.h08 v07.006.2015054055144.hdf")	Data product input files.	
GringPointLongitude	(-149.036243467926, -168.69006752598, -161.565051177078, -135.0)	These latitude and longitude pairs of points when connected in a clockwise series form a polygon of the grid coverage. Always represents the outer ring of coverage.	
GringPointLatitude	(64.7960762144739, 68.0022229499443, 76.4093548376422, 71.7316687660085)		
GringPointSequence No	(1,2,3,4)		
ExclusionGRingFlag	"N"		

RangeEndingDate	" 2002-05-23"	Beginning and ending times of the earliest and latest swaths mapped into the tile. Formats are; yyyy-mm-dd hh:mm:ss.ssssss
RangeEndingTime	" 23:35:00.000000"	
RangeBeginningDate	" 2002-05-23"	
RangeBeginningTime	" 00:25:00.000000 "	
PGEVersion	"6.0.0"	Version of production generation executable.
AncillaryInputPointer	"MOD03.A2002143.2330.006 .2012254203722.hdf"	Name of the geolocation file.
AncillaryInputType	"Geolocation"	Type of ancillary data referenced by pointer.
AssociatedSensorShortName	"MODIS"	Sensor name.
AssociatedPlatformShortName	"Terra"	Platform name.
AssociatedInstrumentShortName	"MODIS"	Instrument and sensor name are the same.
Product Specific Attributes (PSA)		
QAPERCENTGOODQUALITY	56	Summary quality of data range checks done in the algorithm.
QAPERCENTOTHERQUALITY	44	
HORIZONTALTILENUMBER	08	Tile coordinates in longitude direction (NP:0-18, SP 0-18)
VERTICALTILENUMBER	07	Tile coordinates in latitude direction (NP:0-18, SP 20-38)
TileID	31008007	Format is;pshhhvvv p – projection code s – size (1 is full size) hhh – horizontal tile number vvv – vertical tile number
SEAICEPERCENT	2	Summary percentage of sea ice detected (0 – 100).
identifier_product_doi	"10.5067/MODIS/MOD29P1D .006"	Sources of additional information on the product – not currently enabled.
identifier_product_doi_authority	"http://dx.doi.org"	

Table B.3. MOD29P1D or MOD29P1N ArchiveMetadta.0 objects.

Object Name	Typical Value	Comment
CHARACTERISTICBINANGULARSIZE	71.7250539598207	
CHARACTERISTICBINSIZE	1.00270100e+03	
GEOANYABNORMAL	"False"	
GEOESTMAXRMSERROR	50.0	Estimated maximum

		error in geolocation of the data in meters.
DATACOLUMNS	951	
DATAROWS	951	
GLOBALGRIDCOLUMNS	18069	
GLOBALGRIDROWS	18069	
NUMBEROFOVERLAPGRA NULES	15	Number of staged granules that were mapped into this tile.
NUMBEROFINPUTGRANUL ES	30	Total number Of MOD29 input granules staged.
COVERAGECALCULATION METHOD	"volume"	
AlgorithmPackageAcceptanc eDate	"10-2004"	Algorithm version information. Format is mm-yyyy.
AlgorithmPackageMaturityCo de	"Normal"	
AlgorithmPackageName	"MOD_PR29A1"	
AlgorithmPackageVersion	"5"	
LongName	"MODIS/Terra Sea Ice Extent Daily L3 Global 1km EASE-Grid Day"	Descriptive name of the product. Maybe displayed as the product name in the EOS data search tools.
InstrumentName	"Moderate Resolution Imaging SpectroRadiometer"	Long name of MODIS
PLATFORMSHORTNAME	"Terra"	
LOCALINPUTGRANULEID	"MOD29PGD.A2002143.h08v07.006.20150 54055246.hdf, MODMGPGD.A2002143.h08v07.006.20150 54055144.hdf, MODPTPGD.A2002143.h08v07.006.20150 54055057.hdf"	Input products.
Processing Center	"MODAPS"	MODIS Adaptive Processing System
ProcessingDateTime	"2015-02-23T05:52:53.000Z"	Date of processing. Format is; yyyy-mmddThh:mm:ss.sssZ
SPSOParameters	"none"	Not used.

LocalInputGranuleID	("MOD021KM.A2002143.2330.006.2014232003420.hdf", "MOD35_L2.A2002143.2330.006.2014312092819.hdf", "MOD03.A2002143.2330.006.2012254203722.hdf")	Names of MODIS input files.
NorthBoundingCoordinate	76.4093548376422	Bounding rectangle of tile. Format is decimal degrees.
SouthBoundingCoordinate	64.7960762144739	
EastBoundingCoordinate	-135.0	
WestBoundingCoordinate	-168.69006752598	
Processing Environment	"Linux minion5679 2.6.18-400.1.1.el5 #1 SMP Thu Dec 18 00:59:53 EST 2014 x86_64 x86_64 x86_64 GNU/Linux"	Location of processing.
DESCRRevison	"6.0"	Descriptor file associated with the PGE.

Table B.4. MOD29P1D or MOD29P1N product specific global attributes.

Attribute Name	Typical Value	Comment
HDFEOS Version	HDFEOS_V2.17	Version of HDF_EOS.
MOD29InputGranuleNames	MOD29.A2002143.0025.006.2015054052444.hdf,MOD29.A2002143.0200.006.2015054052252.hdf,MOD29.A2002143.0205.006.2015054052252.hdf,MOD29.A2002143.0335.006.2015054052539.hdf,MOD29.A2002143.0340.006.2015054052523.hdf,MOD29.A2002143.0515.006.2015054052617.hdf,MOD29.A2002143.0650.006.2015054052436.hdf,MOD29.A2002143.0655.006.2015054052729.hdf,MOD29.A2002143.0830.006.2015054052518.hdf,MOD29.A2002143.0835.006.2015054053027.hdf,MOD29.A2002143.1010.006.2015054053010.hdf,MOD29.A2002143.2015.006.2015054052808.hdf,MOD29.A2002143.2150.006.2015054052714.hdf,MOD29.A2002143.2155.006.2015054052743.hdf,MOD29.A2002143.2330.006.2015054052706.hdf	Listing of the MOD29 input products.
SCF Algorithm Version	"$Id:MOD_PR29A1_…"	Internal SCF version of the code modules, obsolete.
identifier_product_doi	10.5067/MODIS/MOD29P1D.006	Sources of additional information on the product – not currently enabled.
identifier_product_doi_authority	http://dx.doi.org	

Appendix C

The MOD29E1D product metadata tables are given in this appendix. CoreMetadata.0, ArchiveMetadata.0 and product specific metadata objects are global attributes containing information about product inputs and outputs. StructMetadata.0 attribute contains information about the hemispheric projection.

New global attributes of *identifier_product_doi* and *identifier_product_doi_authority* may, in the future, be used to find information about the product.

Table C.1. Listing of the grid structure metadata in MOD29E1D.
StructMetadata.0   DFNT_CHAR8
GROUP=SwathStructure
END_GROUP=SwathStructure
GROUP=GridStructure
        GROUP=GRID_1
                GridName="MOD_Grid_Seaice_4km_North"
                XDim=4501
                YDim=4501
                UpperLeftPointMtrs=(-9026314.402000,9026314.402000)
                LowerRightMtrs=(9026314.402000,-9026314.402000)
                Projection=GCTP_LAMAZ
                ProjParams=(6371228,0,0,0,0,90000000,0,0,0,0,0,0,0)
                SphereCode=0
                GridOrigin=HDFE_GD_UL
                GROUP=Dimension
                END_GROUP=Dimension
                GROUP=DataField
                        OBJECT=DataField_1
                                DataFieldName="Sea_Ice_by_Reflectance_NP"
                                DataType=DFNT_UINT8
                                DimList=("YDim","XDim")
                                CompressionType=HDFE_COMP_DEFLATE
                                DeflateLevel=9
                        END_OBJECT=DataField_1
                        OBJECT=DataField_2
                                DataFieldName="Ice_Surface_Temperature_NP"
                                DataType=DFNT_UINT16
                                DimList=("YDim","XDim")
                                CompressionType=HDFE_COMP_DEFLATE
                                DeflateLevel=9

```
                END_OBJECT=DataField_2
            END_GROUP=DataField
            GROUP=MergedFields
            END_GROUP=MergedFields
        END_GROUP=GRID_1
        GROUP=GRID_2
            GridName="MOD_Grid_Seaice_4km_South"
            XDim=4501
            YDim=4501
            UpperLeftPointMtrs=(-9026314.402000,9026314.402000)
            LowerRightMtrs=(9026314.402000,-9026314.402000)
            Projection=GCTP_LAMAZ
            ProjParams=(6371228,0,0,0,0,-90000000,0,0,0,0,0,0,0)
            SphereCode=0
            GridOrigin=HDFE_GD_UL
            GROUP=Dimension
            END_GROUP=Dimension
            GROUP=DataField
                OBJECT=DataField_1
                    DataFieldName="Sea_Ice_by_Reflectance_SP"
                    DataType=DFNT_UINT8
                    DimList=("YDim","XDim")
                    CompressionType=HDFE_COMP_DEFLATE
                    DeflateLevel=9
                END_OBJECT=DataField_1
                OBJECT=DataField_2
                    DataFieldName="Ice_Surface_Temperature_SP"
                    DataType=DFNT_UINT16
                    DimList=("YDim","XDim")
                    CompressionType=HDFE_COMP_DEFLATE
                    DeflateLevel=9
                END_OBJECT=DataField_2
            END_GROUP=DataField
            GROUP=MergedFields
            END_GROUP=MergedFields
        END_GROUP=GRID_2
    END_GROUP=GridStructure
    GROUP=PointStructure
    END_GROUP=PointStructure
    END
```

Table C.2. MOD29E1D CoreMetadata.0 objects.

Object Name	Sample Value	Comment
ReprocessingPlanned	"further update is anticipated"	Expect that products will be reprocessed one or more times.
ReprocessingActual	"reprocessed"	Reprocessed means data has been processed before. Processed once means this is the first processing of the data.
LocalGranuleID	"MOD29E1D.A2002143.006. 2015054060612.hdf"	Filename of product. Format is EDST.Ayyyyddd.hhmm.vvv.yyyydddh hmmss.hdf. Time in UTC.
DayNightFlag	"Day"	Day means entire swath in daylight. Both means that part of swath lies in darkness. Night means entire swath in darkness.
ProductionDateTime	"2015-02-23T06:06:12.000Z"	Date and time the file was produced. Format is; yyyy-mm-ddThh:mm:ss.sssZ
LocalVersionID	"SCF V5.0.0"	Version of algorithm delivered from the SCF
PARAMETERNAME	"Sea_Ice_by_Reflectance_N P"	
AutomaticQualityFlag	"Passed"	Default setting because no automated QA checks are done.
AutomaticQualityFLag Explanation	"No automatic quality assessment done in the PGE "	No automated QA checks made during execution of the algorithm.
ScienceQualityFlag	"Not Investigated"	See ScienceQualityFlagExplanation for current information.
SciencelQualityFlagEx planation	"See http://landweb.nascom.nasa.g ov/cgi-bin/QA_WWW/qaFlagPage.c gi?sat=terra for the product Science Quality status."	URL where updated information on science QA should be posted.
QAPercentMissingDat a	0	Amount of L1B data missing from the tile.
QAPercentCloudCove r	35	Amount of ocean in the hemisphere obscured by clouds.
ParameterName	"Ice_Surface_Temperature_N P"	QA parameters given apply to the listed data fields.
AutomaticQualityFlag	"Passed"	Default setting because no automated QA checks are done.
AutomaticQualityFLag Explanation	"No automatic quality assessment done in the PGE "	No automated QA checks made during execution of the algorithm.
ScienceQualityFlag	"Not Investigated"	See ScienceQualityFlagExplanation for current information.
SciencelQualityFlagEx	"See	URL where updated information on

planation	http://landweb.nascom.nasa.gov/cgi-bin/QA_WWW/qaFlagPage.cgi?sat=terra for the product Science Quality status."	science QA should be posted.
QAPercentMissingData	1	Amount of L1B data missing from the swath.
QAPercentCloudCover	35	Amount of land in the swath obscured by clouds.
ParameterName	"Sea_Ice_by_Reflectance_SP"	
AutomaticQualityFlag	"Passed"	Default setting because no automated QA checks are done.
AutomaticQualityFLagExplanation	"No automatic quality assessment done in the PGE"	No automated QA checks made during execution of the algorithm.
ScienceQualityFlag	"Not Investigated"	See ScienceQualityFlagExplanation for current information.
SciencelQualityFlagExplanation	"See http://landweb.nascom.nasa.gov/cgi-bin/QA_WWW/qaFlagPage.cgi?sat=terra for the product Science Quality status."	URL where updated information on science QA should be posted.
QAPercentMissingData	22	Amount of L1B data missing from the swath. QAPercentMissingData
QAPercentCloudCover	56	Amount of land in the swath obscured by clouds. QAPercentCloudCover
ParameterName	"Ice_Surface Temperature_SP"	
AutomaticQualityFlag	"Passed"	Default setting because no automated QA checks are done.
AutomaticQualityFLagExplanation	"No automatic quality assessment done in the PGE"	No automated QA checks made during execution of the algorithm.
ScienceQualityFlag	"Not Investigated"	See ScienceQualityFlagExplanation for current information.
SciencelQualityFlagExplanation	"See http://landweb.nascom.nasa.gov/cgi-bin/QA_WWW/qaFlagPage.cgi?sat=terra for the product Science Quality status."	URL where updated information on science QA should be posted.
QAPercentMissingData	0	Amount of L1B data missing from the swath.
QAPercentCloudCover	65	Amount of ocean in the swath obscured by clouds.

ShortName	"MOD29E1D"	ESDT name of product
VersionID	6	Indicates the EOSDIS Collection
InputPointer	MOD29P1D*	Listing of all the MOD29P1D products for the day.
LOCALITYVALUE	"Global"	
NORTHBOUNDINGCOORDINATE	90.0	
SOUTHBOUNDINGCOORDINATE	-90.0	
EASTBOUNDINGCOORDINATE	180.0	
WESTBOUNDINGCOORDINATE	-180.0	
RangeBeginningTime	" 00:00:00"	Beginning and ending times of the earliest and latest data mapped. Formats are; yyyy-mm-dd hh:mm:ss
RangeEndingTime	" 23:59:59"	
RangeBeginningDate	" 2002-05-23"	
RangeEndingDate	" 2002-05-23"	
PGEVersion	"6.0.1"	Version of production generation executable.
AssociatedSensorShortName	"MODIS"	Sensor name.
AssociatedPlatformShortName	"Terra"	Platform name.
AssociatedInstrumentShortName	"MODIS"	Instrument and sensor name are the same.
identifier_product_doi	"10.5067/MODIS/MOD29E1D.006"	Sources of additional information on the product – not currently enabled.
identifier_product_doi_authority	"http://dx.doi.org"	

Table C.3. MOD29E1D ArchiveMetadta.0 objects.

Object Name	Typical Value	Comment
GLOBALGRIDCOLUMNS	4501	
GLOBALGRIDROWS	4501	
NUMBEROFINPUTGRANULES	197	Total number Of MOD29P1D input granules.
AlgorithmPackageAcceptanceDate	"12-2004"	Algorithm version information.
AlgorithmPackageMaturityCode	"Normal"	
AlgorithmPackageName	"MOD_PR29E1"	
AlgorithmPackageVersion	"5"	
LongName	"MODIS/Terra Sea Ice Extent and IST Daily L3 Global 4km EASE-Grid Day"	Descriptive name of the product. Maybe displayed as the product name in the EOS data search

		tools.
InstrumentName	"Moderate Resolution Imaging SpectroRadiometer"	Long name of MODIS
PLATFORMSHORTNAME	"Terra"	
Processing Center	"MODAPS"	MODIS Adaptive Processing System
ProcessingDateTime	"2015-02-23T01:06:09.000000Z"	Date of processing. Format is; yyyy-mm-ddThh:mm:ss.sssZ
SPSOParameters	"none"	Not used.
DESCRRevison	"6.0"	Descriptor file associated with the PGE.
Processing Environment	"Linux minion5688 2.6.18-400.1.1.el5 #1 SMP Thu Dec 18 00:59:53 EST 2014 x86_64 x86_64 x86_64 GNU/Linux"	Location of processing.
CHARACTERISTICBINANGULARSIZE	287.936014219062	
CHARACTERISTICBINSIZE	4.01080400e+03	

Table C.4. MOD29E1D product specific global attributes.

Attribute Name	Typical Value	Comment
HDFEOS Version	HDFEOS_V2.17	Version of HDF_EOS.
identifier_product_doi	10.5067/MODIS/MOD29E1D.006	Sources of additional information on the product – not currently enabled.
identifier_product_doi_authority	http://dx.doi.org	