**Fire detection**

**MODIS instrument\_MOD14/MYD14 (level 2,collection 6.1) product**

* **About Mission: Terra (EOS/AM-1) and Aqua (EOS/PM-1)**

The objective of the mission is to obtain information about the physical and radiative properties of clouds (ASTER, CERES, MISR, MODIS); air-land and air-sea exchanges of energy, carbon, and water (ASTER, MISR, MODIS); measurements of trace gases (MOPITT); and volcanology (ASTER, MISR, MODIS). Complemented by aircraft and ground-based measurements, Terra data will enable scientists to distinguish between natural and human-induced changes. (Kramer H. J.)

The focus of the Aqua mission is the multi-disciplinary study of the Earth's water cycle, including the interrelated processes (atmosphere, oceans, and land surface) and their relationship to Earth system changes. The data sets of Aqua provide information on cloud formation, precipitation, and radiative properties, air-sea fluxes of energy, carbon, and moisture (AIRS, AMSU, AMSR-E, HSB, CERES, MODIS); and sea ice concentrations and extents (AMSR-E). (Kramer H. J., Aqua)

* **About Instrument: Moderate-resolution Imaging Spectroradiometer (MODIS)**

MODIS is an optomechanical imaging spectroradiometer (whiskbroom type), consisting of a cross-track scan mirror (continuously rotating double-sided scan mirror assembly) and collecting optics, and a set of linear detector arrays with spectral interference filters located in four focal planes.

**Measurement Science**

MODIS Instrument IFOV (spatial resolution) = 1000 m (bands 8-36) with 10 detectors per band are used to detect cloud/surface temperature at an absolute temperature accuracy of 0.2 K for oceans and 1 K for land. The fire detection strategy is based on absolute detection of a fire (when the fire strength is sufficient to detect), and on detection relative to its background (to account for variability of the surface temperature and reflection by sunlight). (Kramer H. J., Terra)

**Onboard Calibration**

MODIS onboard calibration employs various techniques for comprehensive verification of spectral, radiometric and spatial measurements.

They include: Spectro radiometric Calibration Assembly (SRCA), Blackbody (BB) calibration of thermal bands on every scan (a v-groove blackbody), Solar Diffuser (SD) reference, Solar Diffuser Stability Monitor (SDSM). (Kramer H. J., Terra)

* **About MODIS Thermal Anomalies/Fire product (MOD14/MYD14)**

MODIS Thermal Anomalies/Fire products are primarily derived from MODIS 4- and 11-micrometer radiances. The product includes fire occurrence (day/night), fire location, the logical criteria used for the fire selection, detection confidence, Fire Radiative Power and numerous other layers describing fire pixel attributes. The product distinguishes between fire, no fire and no observation. (Frazier, MODIS Thermal Anomalies/Fire, n.d.)

**About MOD14 v061 product**

The Moderate Resolution Imaging Spectroradiometer (MODIS) Thermal Anomalies and Fire MOD14 Version 6.1 product (MOD14 v061) is used to generate all of the higher level fire products, but can also be used to identify fires and other thermal anomalies, such as volcanoes. (Berrick)

In the MOD14 product the second alphabet ‘O’ denotes data from **Terra satellite**

*Platform:* Terra (EOS/AM-1) satellite

*Instrument:* Moderate-resolution Imaging Spectroradiometer (MODIS)

*Launch date:* February 1999

Prime contractor is Raytheon SBRS, Goleta, CA, formerly Hughes SBRS

*Spatial coverage:* Global, (90.0°, 180.0°), (-90.0°, -180.0°)

*Spatial resolution:*  1 km(nadir)

*Swath Dimensions:* 2,030 kilometers along track (long), and 2,300 kilometers across track (wide) at 110º FOV; scan rate = 20.3 rpm across track.

*Orbit:* Sun-synchronous circular orbit, altitude = 705 km, inclination = 98.5º, period = 99 minutes (16 orbits per day, 233 orbit repeat cycles). The descending nodal crossing is at 10:30 AM.

*Data access source:* Earth data

*Filename:* MOD14 - MODIS/Terra Thermal Anomalies/Fire 5-Min L2 Swath 1km V061

*Data temporal extent:* 24 February 2000 - ongoing

*Temporal resolution:* daily, 5-minutes temporal satellite increments (swaths) at 1 km spatial resolution

*Data lag period:* ~10hours

*Native Format:* HDF4

**About MYD14 v061 product** (Kramer H. J., Aqua)

The Aqua Moderate Resolution Imaging Spectroradiometer (MODIS) Thermal Anomalies and Fire MYD14 Version 6.1 product (MYD v061) is used to generate all of the higher-level fire products but can also be used to identify fires and other thermal anomalies, such as volcanoes. (Berrick, MYD14)

In the MYD14 product the second alphabet ‘Y’ denotes data from **Aqua satellite**

*Platform:* Aqua (EOS/PM-1) satellite (signifying its afternoon equatorial crossing time)

*Instrument:* Moderate-resolution Imaging Spectroradiometer (MODIS)

*Launch date:* 04 May 2002

Prime contractor is Raytheon (SBRS) funded by NASA/GFSC

*Spatial coverage:* Global, (90.0°, 180.0°), (-90.0°, -180.0°)

*Spatial resolution:*  1 km(nadir) for bands 8-36 with 10 detectors per band used to detect cloud/surface temperature (absolute temperature accuracy of 0.2 K for oceans and 1 K for land)

*Swath Dimensions:* 2,030 kilometers along track (long), and 2,300 kilometers across track (wide) at 110º FOV; scan rate = 20.3 rpm across track.

*Orbit:* Sun-synchronous circular orbit, altitude = 705 km (nominal), inclination = 98.2º, local equator crossing at 13:30 (1:30 PM) on ascending node, period = 98.8 minutes, the repeat cycle is 16 days (233 orbits).

*Data access source:* Earth data

*Filename:* MYD14 - MODIS/Aqua Thermal Anomalies/Fire 5-Min L2 Swath 1km V061

*Data temporal extent:* 04 July 2002 - ongoing

*Temporal resolution:* daily, 5-minutes temporal satellite increments (swaths) at 1 km spatial resolution

*Data lag period:* ~10hours

*Native Format:* HDF4

* **MOD14/MYD14 level2 collection 6.1 product- Validation and version improvements**

Validation at stage 3 (<https://modis-land.gsfc.nasa.gov/MODLAND_val.html> ) has been achieved for all MODIS Thermal Anomalies and Fire products. Further details regarding MODIS land product validation for the MOD14 data product is available from the MODIS land team validation site (<https://modis-land.gsfc.nasa.gov/ValStatus.php?ProductID=MOD14>). (Berrick)

Improvements/Changes from Previous Versions: (Berrick) : The Version 6.1 Level-1B (L1B) products have been improved by undergoing various calibration changes that include: changes to the response-versus-scan angle (RVS) approach that affects reflectance bands for Aqua and Terra MODIS, corrections to adjust for the optical crosstalk in Terra MODIS infrared (IR) bands, and corrections to the Terra MODIS forward look-up table (LUT) update for the period 2012 - 2017.A polarization correction has been applied to the L1B Reflective Solar Bands (RSB).

* **Data Quality Control** (Louis Giglio, 2021)

*FP confidence:* Fire-pixel confidence classes associated with the confidence level (C) computed for each fire pixel.

Range Confidence Class

0% ≤ C < 30% low

30% ≤ C < 80% nominal

80% ≤ C ≤ 100% high

Three classes of fire pixels (low confidence, nominal confidence, high confidence) are provided in the fire masks of the MODIS Level 2 and Level 3 fire products. Users requiring fewer false alarms may wish to consider only nominal- and high-confidence fire pixels, and treat low-confidence fire pixels as clear, non-fire, land pixels. Users requiring maximum fire detectability, who can tolerate a higher incidence of false alarms, should consider all three classes of fire pixels.

The algorithm examines each pixel of the MODIS swath, and ultimately assigns to

each one of the following classes: *missing data*, *cloud*, *water*, *non-fire*, *fire*, or *unknown*. Processing continues the remaining clear land pixels. Additional specialized tests are used to eliminate false detections caused by sun glint, desert boundaries, errors in the water mask, and small forest clearings. Candidate fire pixels that are not rejected while applying these tests are assigned a class of *fire*. Pixels for which the background characterization could not be performed, i.e., those having an insufficient number of valid pixels, are assigned a class of *unknown*.

* **Collection 6 Known Problems** (Louis Giglio, 2021)

1. Pre-November 2000 Data Quality Prior to November 2000, the Terra MODIS instrument suffered from several hardware problems that adversely affected all of the MODIS fire products
2. Detection Confidence in the Collection 4 fire product did not adequately identify highly questionable, low confidence fire pixels. Such pixels,

which by design should have a confidence close to 0%, were too often assigned much higher confidence estimates of 50% or higher. While an adjustment implemented in the Collection 5 code partially mitigated this problem, some highly questionable fire pixels are still classified as nominal confidence fires. A second minor adjustment was implemented for Collection 6 to help correct this problem.

1. Some non-fire static hot-spot sources are unflagged as such in the *type* field of theMCD14ML product.
2. August 2020 Aqua Outage for 2 weeks

A failure of the Aqua formatter-multiplexer unit (FMU) on 16 August 2020 led to the loss of regular science data telemetry for a period of about two weeks. During this time the MODIS instrument remained otherwise functional, and an effort was made to generate the standard Aqua science products from Direct Broadcast Aqua MODIS data collected by Direct Readout ground stations around the world.

* **Product Validation**

Validation of the Terra MODIS active fire product has primarily been performed using coincident,high resolution fire masks derived from Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) imagery. See Morisette et al. (2005a,b), Csiszar et al. (2006), and Schroeder et al. (2008) for details. A very brief (though now somewhat obsolete) discussion of the general validation procedure, with some early results, can be found in Justice et al. (2002). For information about the methodology for producing the ASTER fire masks, see Giglio et al. (2008).

More recent work described has achieved Stage 3 validation of the Level 2 Terra MODIS fire product using 2500 ASTER scenes distributed globally and acquired from 2001 through 2006 (Figure 10). See Giglio et al. (2016) for details.

* **Why didn’t MODIS detect a particular fire?**

This can happen for any number of reasons. The fire may have started and ended in between satellite overpasses. The fire may be too small or too cool to be detected in the 1 km2 MODIS footprint.

Cloud cover, heavy smoke, or tree canopy may completely obscure a fire. Occasionally the MODIS instruments are inoperable for extended periods of time (e.g. the Terra MODIS in September 2000) and can of course observe nothing during these times.

* **The Level 3 MOD14A1/MYD14A1, tile based, fire pixel detected in each grid with daily maximum value composite for 8-days packed into single file.**
* **The Level 3 MOD14A2/MYD14A2, tile based, fire pixel detected in each grid with maximum value composite for all 8-days**
* **Terra's orbit around the Earth is timed so that it passes from north to south across the equator in the morning (10:30AM), while Aqua passes south to north over the equator in the afternoon(01:30PM). Terra MODIS and Aqua MODIS are viewing the entire Earth's surface every 1 to 2 days.** (Frazier, n.d.)
* **For more information**
* MODIS thermal anomalies/Fire product

<https://modis.gsfc.nasa.gov/data/dataprod/mod14.php>

* For complete information about known issues please refer to: <https://landweb.modaps.eosdis.nasa.gov/cgi-bin/QS/new/pages.cgi?name=known_issues&_ga=2.28489589.87312636.1662651805-268323699.1660396747>
* MODIS Collection 6 Active Fire Product User’s Guide Revision C:

<https://modis-fire.umd.edu/files/MODIS_C6_Fire_User_Guide_C.pdf>

* Details EOS instruments performance, quality analysis, validation:

<https://gis-lab.info/docs/justice02_the_modis_fire_products.pdf>

<https://ntrs.nasa.gov/api/citations/20020038850/downloads/20020038850.pdf>