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Sentinel Hotspots Product Description

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Table of Contents

Document History

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1.4	29/7/2016	Edits to incorporate new data source	U32789	

A Hotspots – Summary Description

Sheet A.1 Definition and Usage

Name	Sentinal Hotspots
Abbreviation	Hotspots
Introduction	• Hotspots are point data, derived from (a growing number of) satellite-born instruments that detect light in the thermal wavelengths. Typically, the satellite data are processed with a specific algorithm that highlights areas with an unusually high temperature. In principle, however, Hotspots may be sourced from non-satellite sources. • Hotspot sources include the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor aboard the National Aeronautics and Space Administration (NASA) Terra and Aqua satellites, the Advanced Very High Resolution Radiometer (AVHRR) night time imagery from the National Oceanic and Atmospheric Administration (NOAA) satellites, the Visible Infrared Imaging Radiometer Suite (VIIRS) on the Suomi- NPP satellite and the Advanced Himawari Imager (AHI) sensor aboard the Japan Meteorological Agency (JMA) on the Himawari-8 satellite.
Key Features	• Updated several times each day. New Hotspots are generated as soon as possible after a data stream is received; typically, 30 minutes after an overpass of the Aqua and Terra satellites and XX minutes after the Himawari-8 satellite. For a given location in Australia updates are generally 144 times each day.
Usage	• Hotspots are useful to detect possible active fires in some circumstances. Taken as an ensemble, the Hotspots provide an overview of fire activity in Australia and capture the pattern of actual fires across the Australian continent through time. • Emergency management agencies use the Hotspots as one of many operational data feeds to inform their broad situational awareness of, and at times tactical response to, fires.
Limitations	See also Accuracy and Limitations, in the Specifications section. • False positives are possible (showing a Hotspot without an underlying cause). • False negatives are possible (failing to show a Hotspot, despite a heated land surface, fire etc.). • Hotspots may indicate phenomena other than fires when locations are identified as 'hot' for some other reason, such as black soil, gas fires, industry and hot rocks. • Not all fires will be detected as Hotspots. If no satellite has passed over the fire, or if smoke, cloud, distance or topography prevent the instruments from sensing the fire, or if the fire is too small or too cool to produce enough heat, or if there is some other technical failure, no Hotspot will be identified. • The location of the Hotspot on a map is approximate only (as a guide, within 1.5 km of the centre of the observation). • Furthermore, the Hotspot location represents an *area around the point* , dependent on the sensor and the satellite position. With current sensors, this is typically more than one square kilometre.

Sheet A.1 Definition and Usage	
Expected Lifespan	Hotspots are produced on an ongoing basis.
Access	Hotspots are published: • via the Sentinel web site (https://sentinel.ga.gov.au/) • as an historical dataset extracted from the Reference Database. • As TEXT files via File download from web (http://files.sentinel.ga.gov.ga/)
Feedback	Feedback on the Hotspots product should be sent via: earth.observation@ga.gov.au
Further information	The following references may be useful sources of further information. Dyce, P.. Woolner, J., and Marks, A. (2005) Technical Implementation of the Sentinel Hotspots Web-Based Pilot Wildfire Mapping System in Australia. CSIRO Land and Water unpublished report. http://www.aprsaf.org/data/malaysia_tecshop_data/Part1_Sentinel_Implement.pdf http://www.aprsaf.org/data/malaysia_tecshop_data/Part2_Sentinel_Implement.pdf Hudson, D., and Mueller, N. (2009) Fighting fire with satellite dataset: Satellite imagery aids emergency relief. AUSGEO News 94, Geoscience Australia, Canberra. Koltunov, A., and Ustin, S.L. (2007) Early fire detection using non-linear multitemporal prediction of thermal imagery. *Remote Sensing of Environment* **110**, 18-28. http://www.opengeospatial.org/standards/wfs Reddy, S. (2005) Sentinel finds a permanent home at Geoscience Australia. AUSGEO News 80, Geoscience Australia, Canberra

B Hotspots - Specification

Sheet B.1 Provenance and Algorithms		
Data Sources	**Primary**	Moderate Resolution Imaging Spectroradiometer - MODIS (Terra and Aqua)
		Advanced Very High Resolution Radiometer (AVHRR) Night Time Imagery (NOAA–18 and –19)
		Visible Infrared Imaging Radiometer (VIIRS) (Suomi NPP)
		Advanced Himawari Imager (AHI) Himawari-8
	Ancillary	Predicted satellite ephemeris data (location and attitude of the satellite)
		Two Line Element (TLE) files
		Scan zenith angle and azimuth
		Solar zenith and azimuth
	Satellite image Metadata	Emissivity
		Acquisition day and time (in UTC) to compute sun position
		Image Size (number of pixels and lines)
		Image Cell Size
		Location of the north-west corner of the image
		Location of the centre of the image
Major Algorithms	• The MODIS Hotspots methodology is based on the MOD14 (Terra) and MYD14 (Aqua) Fire Image product (Justice *et al.*, 2002). These products compute brightness temperatures from two 4μm channels (21 and 22, which saturate at different temperatures) and channel 31 (11μm). Other channels are used to exclude 'bright', non-fire pixels (channels 1, 2 and 7) or cloud (channels 1, 2, 7 and 32) (Giglio *et al.*, 2003; Justice *et al.*, 2006). • The AVHRR Hotspots product is produced using a 'contextual fire detection algorithm' originaly developed by Giglio *et al.* (1999, 2003). It was later modified and validated by Rogers (2006) into pseudo-code for the purpose of Hotspot detection implementation. The algorithm exploits the strong emission of mid-infrared from fires (Dozier 1981; Matson and Dozier, 1981). The contextual fire detection algorithm uses AVHRR 3b and AVHRR 4 infrared images (10-12 μm) which provide information on the temperature of the underlying surface or cloud. • VIIRS fire detection algorithm (VIIRS, AER Version 6) is based on the MODIS Version 4 Fire Mask (Gilio, *et al.*, 2003, Baker *et al.*, 2011). The thermal bands M13 (4.05 μm), M15 (10.763 μm) and M16 (12.013 μm) are converted to brightness temperatures using the VIIRS Sensor Data Record (SDR) interface. SDR processing involves applying calibration (radiometric, geometric, engineering) and geo-locating using ephemeris and altitude and earth model information. • The AHI Hotspots product is produced by the GOES-R Advanced Baseline Imager (ABI) Wild Fire Automated Biomass Burning Algorithm (WFABBA) (Dozier 1981; McNamara et al., 2004; Schmidt	

Sheet B.1 Provenance and Algorithms	
	and Prins, 2003). The ABI fire algorithm is a dynamic multispectral thresholding contextual algorithm based on the sensitivitiy of the 3.9 μm band (Channel 7) to high temperature sub-pixel anomalies relative to the less sensitive 11.2 μm window band (Channel 14). The algorithm incorporates statistical techniques (decision tree threshold condition approach) to automatically identify Hotspot pixels in the ABI imagery and provides diurnal fire detection and sub-pixel fire characterisation for data within a satellite view angle of 80°.
Algorithm Version	• MODIS: MOD14_SPA (v. 5.0.1) • AVHRR: (v.1.0.0) • VIIRS-NPP: CSPP SDR v.1.3 and CSPP EDR v1.0 • AHI: WFABBA (v. 6.5.010g)
Validation of Underlying Algorithms	Validation of MODIS Fire Products has used simulated (Giglio *et al.*, 2003; Justice *et al.*, 2006) and acquired (Morisette *et al.*, 2005; Schroeder *et al.*, 2008a, 2008b) ASTER imagery. Validation of the AHI hotspots algorithm occurred through the RMIT University, Geoscience Australia, Landgate Hotspots sourced from other sources are un-validated.
Processing Sequence	Hotspots data acquisition and processing are described below: • ***Data acquisition:*** Satellite telemetry data is received at the Geoscience Australia data acquisition facility ground station at Alice Springs and processed to produce a level 0 (MODIS), NOAA HDF file (AVHRR) and Raw Data Record (VIIRS) datasets. These datasets are then transferred via a network link to Canberra for further processing. • ***Data processing:*** Currently MODIS and AVHRR night time data are processed using MOD14/MYD14 and CATS respectively to produce Hotspots. VIIRS data are processed using the VIIRS SDR algorithm (Baker *et al.*, 2011). Hotspot pixels are identified and extracted from the image into an ASCII file, and are saved in the Geoscience Australia Reference Hotspot database (the Reference database). The Reference database provides a complete and on-going record of Geoscience Australia's Hotspots product (the Reference database attribution details are described in the Attribution for Point-Based Products sub-section) .
Accuracy and Limitations	See also section A1 above. Hotspot data can show false positives, that is locations mapped as fire which are identified as 'hot' for some other reason, such as black soil, gas fires and hot rocks. Smoke and cloud also confound active fire detection. Small and brief fires can also be omitted from hotspot images due to topography (de Klerk, 2008), or because the spatial resolution of the imagery is too coarse, or the timing of the satellite overpass did not coincide with peak fire intensity (Bradley and Millington, 2006; Smith *et al.*, 2007c; Hawbaker *et al.*, 2008). Limitations of the Sentinel Hotspots mapping system include but are not limited to: • The hotspot location on any map (no matter how detailed) is only accurate at best to 1.5 km. • The symbol used for the Hotspot on the maps does not indicate the size of the fire. • Not all Hotspots are detected by the satellites. Some heat sources may be too small, not hot enough, or obscured by thick smoke or cloud.

Sheet B.1 Provenance and Algorithms

- The satellites detect heat sources rather than fires. Hotspots may indicate industrial operations such as furnaces, or other heat sources, rather than fires.

Sheet B.2 Technical Characteristics

Sheet B.2.1 Product Spatial Details

Frequency	Based on available satellite data			
Temporal Extent	MODIS: from 27 August 2002 AVHRR: from 19 October 2006 VIIRS: from December 2013 AHI: from Jan 2016			
Spatial Extent	**Geographic Coverage**	**Min latitude**	-43.005096	
		Min longitude	107.751236	
		Max latitude	-1.042098	
		Max longitude	166.17131	
Geographic Coordinate System Properties	**Datum**	GDA94		
	Ellipsoid	**GRS 1980**	**Semimajor axis**	6378137
			Semiminor Axis	6356752.3
			Inverse Flattening	298.25722210
	Angular Unit	**Unit**	Degrees	
		Radians per Unit	$\pi/180$	
	Prime Meridian	Greenwich		

Sheet B.2 Technical Characteristics

Sheet B.2.2 Attributes

Hotspot Attributes	**Observation Time**	Time of acquisition for the data in which the Hotspot was detected (UTC). This is determined based on the start and the end time of the acquisition. For the current satellites the level of accuracy should be of the order of 5 minutes. Format: MM/DD/YYYY hh:mm:ss AM/PM There are different rules for observation time for different satellites: • AQUA and TERRA (MODIS): the observation time is an estimated value based on the location of the fire pixel within the satellite acquisition and the time range of the acquisition. • NPP and NOAA (VIIRS and AVHRR): the observation time is an estimated value based on the mid-point of the time range of the satellite acquisition. • Himawari-8 (AHI): the observation time is an estimated value based on the location of the fire pixel within the satellite acquisition and the time range of the acquisition.
	Latitude	Hotspot latitude based on WGS84 (°) at centre of fire pixel. Units: signed decimal degrees Format: *-dd.d* Valid Range: -90.000 to +90.000 Uncertainty: the latitude is no more accurate than the pixel size (e.g. MODIS 1km x 1km)
	Longitude	Hotspot longitude based on WGS84 (°) at centre of fire pixel. Units: signed decimal degrees Format: *ddd.d* Valid Range: -180.000 to +180.000 Uncertainty: the longitude is no more accurate than the pixel size (e.g. MODIS 1km x 1km)
	Temperature	In order to detect the presence of fire, a set of detection criteria have been developed. These criteria (which differ for day and night observations) are based on the apparent temperature of the fire pixel and the difference between the fire pixel and its background temperature (Justice, et.al 2006). Units: degrees Kelvin Format: *nnn.n*

Sheet B.2 Technical Characteristics

Sheet B.2.2 Attributes

Power[1]	Estimate of mean radiated power of MODIS Hotspot pixel (based on Justice *et al.*, 2006) detected after April 2008. No Power estimate available for AVHRR Hotspots, VIIRS, or any MODIS Hotspots detected before April 2008. In these cases, no values are displayed. Units: MW/Km^2 Format: *nnn.n* Valid Range: ≥ 0.0 (maximum observed value 1900.0)
Confidence	MOD14 Fire Detection Algorithm indication of the confidence that a hotspot is a fire (Giglio *et al.*, 2003): • 0–30%— "low"; • 30–80%— "nominal"; and • 80–100%—"high"; No Confidence is given for Hotspots detected from AVHRR data. Confidence for VIIRS imagery is given in percentage for each detected Hotspot (0 – 100%). The Confidence attribute is intended to help users to gauge the quality of individual fire pixels within the fire mask. Geoscience Australia displays and provides all Hotspots, regardless of Confidence. Units: none (scalar value) Format: *nnn* Valid Range: 0 - 100
Instrument	The name of the instrument used to detect the Hotspot (e.g. MODIS, VIIRS, AVHRR, AHI)
Orbit Number	The orbit number is determined using the information provided in the NORAD TLE file(s). The TLE file provides reference information for an "epoch" orbit that allows the current orbit to be calculated using the acquisition information.
Algorithm	The name of the algorithm used to produce hotspots Valid values: MOD14/MYD14 CATS

[1] The 'Power' attribute should not be confused with 'Fireline Intensity' which is a ground-based measurement typically taken at the hottest part of the firefront as MW/m.

Sheet B.2 Technical Characteristics

Sheet B.2.2 Attributes

	SDR algorithm
Algorithm Version	Algorithm version number
Satellite	Name of the satellite platform using the "National Space Science Data Center" unique satellite number (*http://nssdc.gsfc.nasa.gov/nmc/*)
Sample Area	Area of land surface represented by the Hotspot. Approximated as the nadir pixel area at the equator. Units m^2. Example: 10000 *(this attribute is not currently produced)*
Delta-Long (optional)	Nominal uncertainty in the estimate of longitude Units m *(this attribute is not currently produced).*
Delta-Lat (optional)	Nominal uncertainty in the estimate of latitude *(this attribute is not currently produced).*
Agency Source	Name of the Agency providing the data
Fire Category Name (AHI hotspots only)	Fire category name field on Web services and website contain Processed and Saturated categories only. Hotspot files on the file transfer site contain all fire category names (Processed, Saturated, Low Possibility, Medium Possibility, High Possibility).

C Hotspots - Availability

Sheet C.1 Licencing and Access	
Support	Supported
Licencing	Creative Commons 4.0 Attribution International licence (CC BY 4.0 International)
Search Tool	Sentinel Web Page: http://sentinel.ga.gov.au/ Supports: Open Geospatial Consortium (OGC) Web Feature Service (WFS), versions 1.0.0, 1.1.0, and 2.0.0. Supports: Open Geospatial Consortium (OGC) Web Map Service (WMS) versions 1.1.1 and 1.3.0.
Preview Facility	Sentinel Web Page: http://sentinel.ga.gov.au/ Supports: Open Geospatial Consortium (OGC) Web Feature Service (WFS), versions 1.0.0, 1.1.0, and 2.0.0. Supports: Open Geospatial Consortium (OGC) Web Map Service (WMS) versions 1.1.1 and 1.3.0.
Ordering and Distribution	Sentinel Web Page: http://sentinel.ga.gov.au/ Via File Download (http://files.sentinel.ga.gov.au/) Supports: Open Geospatial Consortium (OGC) Web Feature Service (WFS), versions 1.0.0, 1.1.0, and 2.0.0. Supports: Open Geospatial Consortium (OGC) Web Map Service (WMS) versions 1.1.1 and 1.3.0.

Sheet C.2 Delivery Information		
Hotspots Standard Product		Standard set of hotspot dataset available through WMS, WFS, KML and RSS: • Hotspots detected in last 2 hours • Hotspots detected in last 6 hours • Hotspots detected in last 24 hours • Hotspots detected in last 48 hours • Hotspots detected in last 72 hours
Hotspots Query Product		Ability to query the historical hotspot database based on satellite, sensor, orbit, date, algorithm, algorithm version, latitude, longitude, temperature, power, confidence level and time.
Hotspots Metadata		XML
Services		The Hotspots product can be obtained via the following data access services: • OGC compliant Web Map Services allowing users to view the Hotspots as a georeferenced composite image (e.g. PNG, GIF, JPEG); • OGC compliant Web Feature Services (WFS) allowing users to obtain the Hotspots as geographical features (e.g. KML, CSV, GML, shapefiles); • Rich Site Summary (RSS) feed enabling users to access the most up to date information about hotspots data and metadata; • File Download enabling users to obtain a 30-day rolling archive of the Hotspots generated from Sentinel and the MODIS mosaic (e.g. TEXT and TIF).
Data Volume	**Historical**	14.9 million records (as at September 2016)
	Per year	9, 311,000 records per year, on average

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Glossary

Aqua	NASA satellite collecting data on Earth's water cycle (USA)
AER	Atmospheric and Environmental Research
ABI	Advanced Baseline Imager
AHI	Advanced Himawari Imager (JMA)
ASTER	Advanced Space-borne Thermal Emission and Reflection Radiometer
CATS	Cloud-Aerosol Transport System
CSPP	Community Satellite Processing Package
EDR	Environmental Data Record
EOS	Earth Observing System (NASA)
GDA	Geocentric Datum of Australia
GOES-R	Geostationary Operational Environmental Satellite
GPX	GPS eXchange Format
JMA	Japan Meteorological Agency
MODIS	MODerate resolution Imaging Spectroradiometer (NASA)
MOD14	MODIS Terra Thermal Anomalies product
MYD14	MYD14 Aqua Thermal Anomalies
MW	Megawatts
NASA	National Aeronautics and Space Administration (USA)
NOAA	National Oceanic and Atmospheric Administration (USA)
NPP	National Polar-orbiting Partnership (USA)
OGC	Open Geospatial Consortium
POES	Polar-orbiting Operational Environmental Satellites
SDR	Sensor Data Record
SUOMI NPP	Satellite mission replacing EOS satellites (NASA)
Terra	NASA satellite collecting data on Earth's land processes (USA)
VIIRS	Visible Infrared Imaging Radiometer Suite
WFS	Web Feature Service
WGS	World Geodetic System
WMS	Web Map Service
XML	Extensible Mark-up Language