Australian Government

Geoscience Australia

Digital Earth Australia Hotspots Product Description

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Unclassified

Department of Industry, Science and Resources
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Geoscience Australia acknowledges the traditional owners and custodians of Country throughout Australia and acknowledges their continuing connection to land, waters and community. We pay our respects to the people, the cultures and the elders past and present.

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Document History

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3.0	25/10/2023	Major document reformat and revalidation, check and update all algorithm versions, update document template, reformat tables, update doco for Himawari-9	U37443	Tom McAdam

Hotspots – Summary Description

Definition and Usage

Name: Digital Earth Australia Hotspots (previously called Sentinel Hotspots)
Abbreviation: DEA Hotspots

What is Digital Earth Australia Hotspots?

Digital Earth Australia (DEA) Hotspots is a national bushfire monitoring system that provides timely information about hotspots to emergency service managers and critical infrastructure providers across Australia. Updated with new information every 10 minutes, the mapping system uses satellite sensors to detect areas producing high levels of infrared radiation (called Hotspots) to allow users to identify potential fire locations with a possible risk to communities and property.

DEA Hotspots is not published in real time and should not be used for safety of life decisions.

There are two versions of the DEA Hotspots system:

- DEA Hotspots public version: https://hotspots.dea.ga.gov.au/
  - Available for anyone to access and use
- DEA Hotspots secure users' version: https://hotspots.dea.ga.gov.au/login
  - Available for emergency managers and associated organisations
  - Provides priority access to the system during periods of high demand
  - Includes additional sources of Hotspot information
  - To apply for access, email earth.observation@ga.gov.au

Sources of Hotspots information

- Digital Earth Australia (DEA) Hotspots is managed by Geoscience Australia (GA) on behalf of its partners.
- Each Hotspot is represented by a spot on the map, 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; a 'Hotspot'. In principle, however, Hotspots may be sourced from non-satellite sources.
- DEA Hotspot sources include the:
  - Moderate Resolution Imaging Spectroradiometer (MODIS) sensor on the National Aeronautics and Space Administration (NASA) Terra and Aqua polar orbiting satellites
  - Advanced Very High Resolution Radiometer (AVHRR) nighttime imagery from the National Oceanic and Atmospheric Administration (NOAA-19) polar orbiting satellite
  - Visible Infrared Imaging Radiometer Suite (VIIRS) on the Suomi National Polar-orbiting Partnership (NPP) satellite and NOAA-20 polar orbiting satellite
  - Advanced Himawari Imager (AHI) sensor operated bythe Japan Meteorological Agency (JMA) on the Himawari-9 geostationary satellite

Table 1: Satellite sources of information in DEA Hotspots and the sensor and algorithms used to generate Hotspots.

Satellite	Sensor	Algorithm
Aqua **Terra**	MODIS	MOD14 Landgate MOD14 Landgate MODIS Daytime Landgate MODIS Nighttime
Himawari-9	AHI	Landgate AHI BRIGHT AHI
NOAA-19	AVHRR	Landgate AVHRR
NOAA-20	VIIRS	AFIMG AFMOD Landgate Daytime VIIRS algorithm Landgate Nighttime VIIRS algorithm
Suomi NPP	VIIRS	AFIMG AFMOD Landgate Daytime VIIRS algorithm Landgate Nighttime VIIRS algorithm

- Hotspots are generated using both visible and thermal sensor information.
- At best, hotspots information is 17 minutes old (this is how long it takes to download and process data into hotspots after each satellite pass).
- The Himawari-9 satellite is a geostationary satellite, which covers Australia at all times, and provides updates every 10 minutes, however the information is not published in real time.
- All other satellites pass over a given area up to 4 times a day, and each pass covers only a part of Australia, which means some fires are not detected because the satellite was not looking over that area at the appropriate time.

How to interpret DEA Hotspots (and how not to…)

- Hotspots can indicate possible active fires in some circumstances. Taken as an ensemble, Hotspots provide an overview of thermal activity in Australia and capture the pattern of possible fires across the Australian continent overtime.
- Emergency management agencies use Hotspots as one of many operational data feeds to inform their broad situationalawareness of, and at times tactical response to, fires.
- DEA Hotspots should not be used for safety of life decisions. For local updates and alerts, please refer to your state emergencyor fire service.
- Hotspots are not presented in real-time and not designed to be used in isolation of other data sources. It is not accurate enough to be relied upon for time-critical detection and location of fires.
- The system is not isolated to emergency service usage; it can also be used by environment and climate change researchers, land managers, media, policy makers and the broader public.

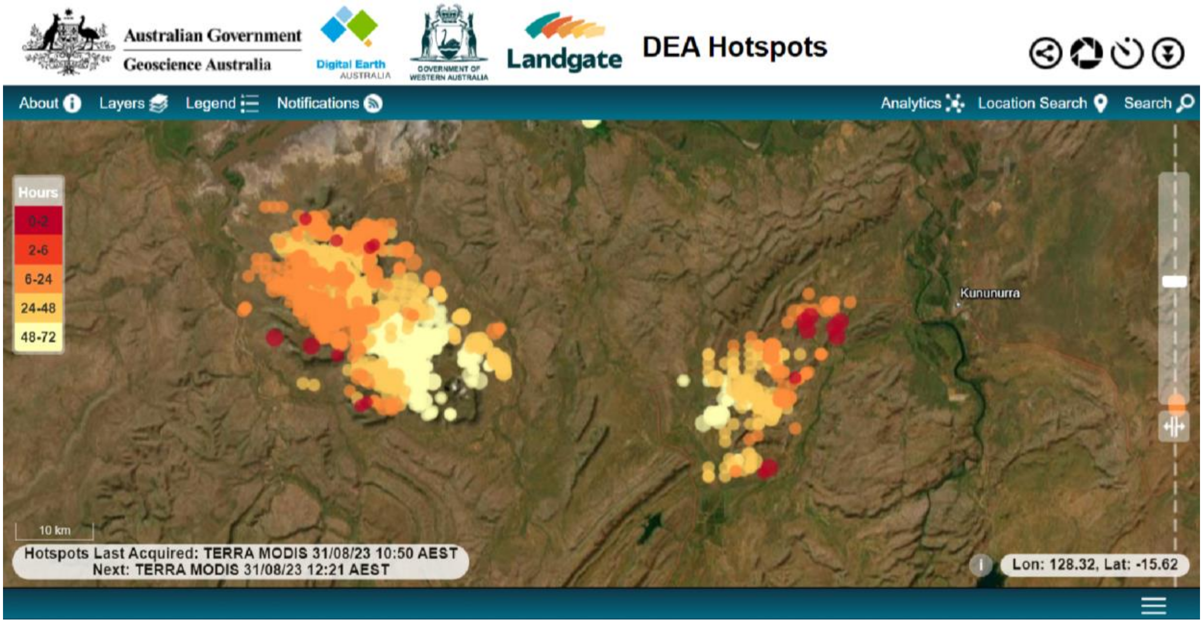

Figure 1: Screen capture from DEA Hotspots showing an example of a fire in northern Western Australia. This interface can be accessed via https://hotspots.dea.ga.gov.au/.

- The colour of the spot represents the time the Hotspot was last observed by a passing satellite (e.g., 0-2 hours) (Figure 1). The colour does not indicate severity.
- The size of the Hotspots does not indicate the size of the fire.
  - If you zoom in on the map you will notice that the size of the Hotspot dot will change.
- The Hotspot location on any map (no matter how detailed) is only accurate to ± 375 m at best (VIIRS).
- False positives (showing a Hotspot without an underlying cause) are possible.
- Hotspots are potential bushfires, but could also indicate other phenomena, such as black soils, gas fires, heavy industry, furnaces, smoke plumes, jet contrails and hot rocks.
- Not all fires will be detected as Hotspots.
- False negatives (failing to show a Hotspot, despite a heated land surface, fire, etc.) are possible. Some heat sources may be too small, not hot enough, or obscured by thick smoke or cloud.
- Small and brief fires can also be omitted from Hotspot images due to topography (de Klerk, 2008), the spatial resolution of the imagery being too coarse, or the timing of the satellite overpass not coinciding with peak fire intensity (Bradley and Millington, 2006; Smith *et al.,* 2007; Hawbaker *et al.,* 2008).
- Depending on the sensor, generally, a flaming or smouldering fire would need to be at least 1,000 m^2 to be recognised as a Hotspot. Under exceptional (and rare) conditions (no cloud, smoke, wind etc.), a flaming fire at 50m^2 may be detected (Giglio *et al*., 2003a).
- Geostationary satellite derived products algorithms may be optimised for day or night conditions. For algorithms such as BRIGHT (Biogeographical Region and Individual Geostationary HHMMSS Threshold algorithm) that provide hotspots every 10 minutes, 24 hours per day, temporal windows approximately +/- 1 hour of sunset andsunrise are considered unreliable periods.
- No Hotspots are produced if satellite data is not received (e.g., for AHI, 0240 and 1440 UTC times are not received).

DEA Hotspots portal data structure

- Data is structured by sensor and then by algorithm, giving the user the ability to turn layers on and off (Figure 2).
- DEA Hotspots may have different algorithms for the same satellite and sensors. E.g., DEA Hotspots has two versions of MOD14, as shown in Figure 2; “MOD14” and “Landgate MOD14”.
- Users can also choose to filter the Hotspots displayed on the map by toggling the slide bars below the sensor drop downs. You can filter the display by:
  - Confidence
  - Temperature (in Kelvin)
  - Power
  - Time that the Hotspot was acquired

Note that not all Hotspot algorithms have the same attributes and some may be missing attributes required to apply some of these filters.

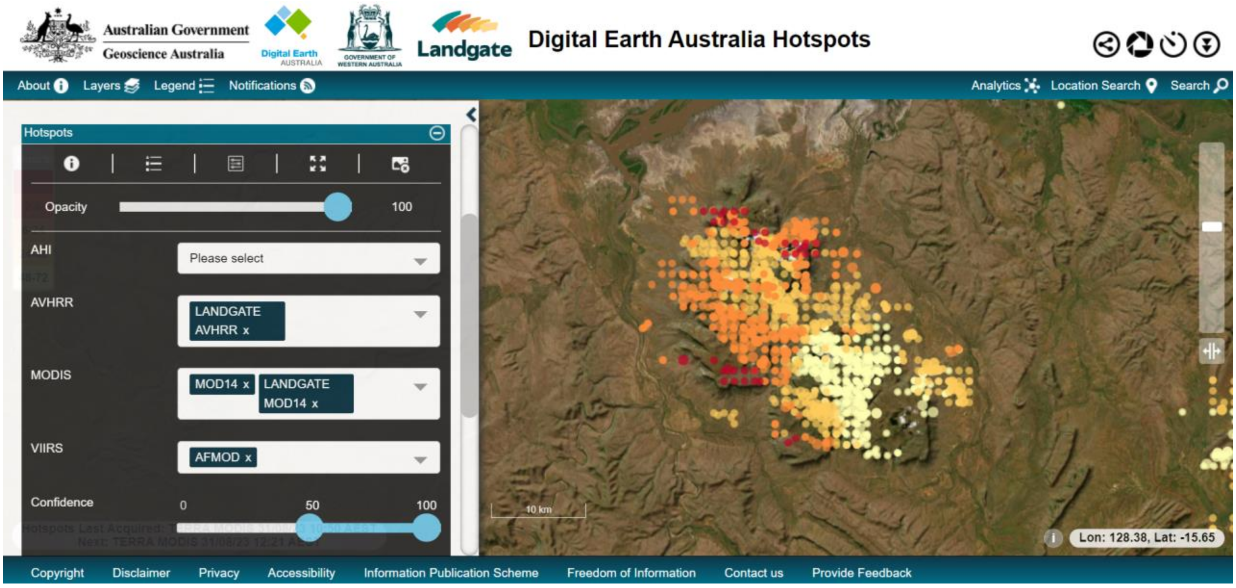

Figure 2: DEA Hotspots portal with the “Layers” panel toggled on the left-hand side of the screen. The Hotspots data here are organised by sensor, with the ability to turn the Hotspots algorithms on and off using the white drop-down menus, or by clicking the “x” next to the algorithm name to turn off an algorithm input.

Contact us

- For feedback or enquiries about DEA Hotspots, please contact earth.observation@ga.gov.au

Additional information

Digital Earth Australia website: https://www.dea.ga.gov.au/products/dea-hotspots

Hotspots – Data Access

DEA Hotspots can be accessed in the following ways:

Interactive web maps

- DEA Hotspots portal: https://hotspots.dea.ga.gov.au/
- National Map: https://nationalmap.gov.au/
- As a layer on DEA Maps: https://maps.dea.ga.gov.au/
  - Explore map data > Hazards

File access

- https://hotspots.dea.ga.gov.au/files

Open Geospatial Consortium (OGC) compliant web services

- Web Map Services (WMS): https://hotspots.dea.ga.gov.au/geoserver/wms?service=wms&version=1.3.0&request=getcapabilities
  - Allows users to view the Hotspots as a georeferenced composite image (e.g., PNG, GIF, JPEG)
  - Supports versions 1.1.1 and 1.3.0
- Web Feature Services (WFS): https://hotspots.dea.ga.gov.au/geoserver/wfs?service=wfs&version=2.0.0&request=getcapabilities
  - Allows users to obtain the Hotspots as geographical features (e.g., KML, CSV, GML, shapefiles)
  - Supports versions 1.0.0, 1.1.0 and 2.0.0

Notification services

- for users to access the last 72 hours of Hotspots data and metadata via:
  - Rich Site Summary (RSS): https://hotspots.dea.ga.gov.au/feeds/last_three_days.rss
  - Geographically Encoded Objects for Rich Site Summary feeds (GeoRSS): https://hotspots.dea.ga.gov.au/geoserver/wfs?service=WFS&request=GetFeature&typeNames=public:hotspots_three_days
  - Keyhole Markup Language (KML): https://hotspots.dea.ga.gov.au/geoserver/wms/kml?layers=public:hotspots_three_days
  - GeoJSON: https://hotspots.dea.ga.gov.au/data/recent-hotspots.json

Text files for the last 30 days

- https://hotspots.dea.ga.gov.au/files/L3/hotspots

Imagery for VIIRS, MODIS and AVHRR

- Image data from which hotspots were derived
- under associated subfolder SRSS
    - e.g., https://hotspots.dea.ga.gov.au/files/L3/hotspots/MODIS/SRSS

GA Historic Hotspot database

- Historical archive of Hotspots since 2002
- https://hotspots.dea.ga.gov.au/files/historic
- See Sheet 4 for more information

Hotspots – Specification

Sheet 1 Provenance and Algorithms

Data Sources	**Primary**	MODIS (Terra and Aqua)
		AVHRR Nighttime Imagery (NOAA-19)
		VIIRS (Suomi NPP, NOAA-20)
		AHI (Himawari-9)
	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
		Emissivity
	Satellite image Metadata	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 (GA)	• **MOD14** – MOD14 Hotspots uses the Terra (MOD14) and Aqua (MYD14) MODIS Thermal Anomalies Collection 6 at 1km resolution (Justice *et al.*, 2002; Giglio *et al.*, 2016b). – These products compute brightnesstemperatures 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*., 2003b; Justice *et al*., 2006). – This version of the algorithm uses dynamic fire thresholding to reduce the number of false positives identified (Giglio *et al*., 2016b). • **AFMOD** – The VIIRS M-band algorithm builds upon the MOD14 Collection 6 product (Giglio *et al.,* 2016b), incorporating code updates and methodological advances (Giglio *et al.,* 2016a). – The product uses channels M13 and M15 to identify candidate fire pixels and compares against the long-wave infrared channel M16 to screen out other radiometrically bright pixels such as clouds or sand. – This algorithm has been implemented at 350m resolution, taking advantage of the I-band resolution	

	of VIIRS (Space Science and Engineering Center, 2022). • **AFIMG** – The VIIRS I-band algorithm is based on the 375m data described in Schroeder *et al*., (2014) and uses a multi-spectral contextual algorithm that highlights sub-pixel thermal anomalies in level 1 data. – VIIRS channel I4 is used as the primary detector of thermal anomalies, and is compared against data from I5, which helps separate the fire-free background (Schroeder *et al.,* 2014; Schroeder and Giglio, 2018; Schroeder *et al.,* 2020).
Algorithm Version (GA)	• **MOD14**: MOD14_SPA v.6.2.1 (Science Processing Algorithm) – Community Satellite Processing Package (CSPP) VIIRS, ATMS and CrIS SDR v.3.3.1 for Suomi NPP and NOAA-20 – CSPP NOAA Active Fire v.2.0.0 • **AFMOD and AFIMG**: v.6 – CSPP VIIRS, ATMS and CrIS SDR v.3.3.1 for Suomi NPP and NOAA-20 – CSPP NOAA Active Fire v.2.0.0
Major Algorithms (Landgate)	• **Landgate MOD14** – The MODIS nighttime algorithm is based on a 'contextual fire detection algorithm' (Lee and Tag, 1990, Flasse and Ceccato, 1996) with extra tests and thresholds modified to suit Australian conditions by Landgate. – The MODIS daytime algorithm is based on the MOD14 (Terra) and MYD14 (Aqua) Fire Image product (Justice et al., 2002) with extra tests for sunglint. • **Landgate AVHRR** – The AVHRR nighttime fire detection algorithm is based ona 'contextual fire detection algorithm' (Lee and Tag, 1990,Flasse and Ceccato, 1996) with extra tests and thresholdsmodified to suit Australian conditions by Landgate. – The AVHRR daytime fire detection algorithm is based on a'contextual fire detection algorithm' with extra tests for cloud and sunglint using the visible bands. • **Landgate VIIRS**: The VIIRS AFIMG product is based on the 375m data described in Schroeder *et al*., (2014) and uses a multi-spectral contextual algorithm that highlights sub-pixel thermal anomalies in level 1 data. SDR processing involves applying calibration (radiometric, geometric, engineering) and geo-locating using ephemeris and altitude and Earth model information. – The VIIRS nighttime algorithm is based on a 'contextual fire detection algorithm' (Lee and Tag,

	1990, Flasse and Ceccato, 1996) with extra tests and thresholds modified tosuit Australian conditions by Landgate. The I4 channel (3.74 µm) is used to detect hotspots at 375m resolution. – The VIIRS daytime algorithm is based on Schroeder *et al*.,2014 with extra tests and thresholds modified to suit Australian conditions by Landgate. • **Landgate AHI** – The AHI nighttime algorithm is based on a 'contextual fire detection algorithm' (Lee and Tag, 1990, Flasse and Ceccato, 1996) with extra tests and thresholds modified tosuit Australian conditions by Landgate. – The AHI daytime fire detection algorithm is based on a'contextual fire detection algorithm' with extra tests forcloud and sunglint using the visible bands.
Algorithm Version (Landgate)	• **Landgate MOD14**: v.6.2.1 IMAPP – MODIS: Landgate Nighttime algorithm v.6.2.1 – MODIS: Landgate Daytime algorithm v.6.2.1 • **Landgate AVHRR:** – AVHRR: Landgate Nighttime algorithm v.1.0 – AVHRR: Landgate Daytime algorithm v.1.0 • **Landgate VIIRS:** – VIIRS: Landgate Nighttime VIIRS algorithm v.6.0 – VIIRS: Landgate Daytime VIIRS algorithm v.6.0 – VIIRS: CSPP SDR v.3.1.1 and AFIMG v.6.0 • **Landgate AHI:** – AHI: Landgate Nighttime algorithm v.1 – AHI: Landgate Daytime algorithm v.1
Major Algorithm (RMIT & BNHCRC)[1]	• **BRIGHT AHI:** – The AHI day and night-time algorithms are based on the enhanced Biogeographical Region and Individual Geostationary HHMMSS Threshold (BRIGHT) algorithm for day and nighttime (Engel et al., 2021a and Engel et al., 2021b). – BRIGHT uses the preceding 28-days to develop a dynamic thresholding for detecting potential hotspots. – All hotspots are available on the Secure version of DEA Hotspots but only hotspots with at least 50% confidence are available on the public version of DEA Hotspots.
Algorithm Version (RMIT & BNHCRC)	**BRIGHT AHI**: BRIGHT AHI v.1.86 (Day and Night)

[1] When using the BRIGHT hotspots for publication purposes, please cite Engel CB, Jones SD, Reinke KJ. (2021) Real-Time Detection of Daytime and Night-Time Fire Hotspots from Geostationary Satellites. *Remote Sensing*.13(9), 1627.

Validation of Underlying Algorithms	• **MODIS** – Validation of MODIS Fire Products has used simulated (Giglio *et al*., 2003b; Justice *et al*., 2006) and acquired (Morisette *et al*., 2005; Schroeder *et al*., 2008a, 2008b) Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) imagery to validate hotspot detection. – MOD14 version 6 algorithm was validated against ASTER imagery that had been categorised for broad tree cover (Giglio *et al*., 2016b). – MOD14 showed the highest detection probability globally over Australia and New Zealand (26%), however this statistic is skewed by the bigger fires observed in Australia and New Zealand which biases the mean to higher values when compared against the large number of small fires, which have a lower detection probability. – MOD14 is more likely to miss fires in areas with low tree cover, where fire intensity is lower and there are warmer background conditions (Giglio *et al*., 2016b). • **BRIGHT** – BRIGHT Hotspots from 01/04/2019 to 31/03/2020 were validated against VIIRS and MODIS hotspots from the same period (Engel *et al*., 2021a and Engel *et al*., 2021b). – The algorithm was shown to perform well over most of Australia, except for urban areas and volcanic landscapes. – Limitations in sensitivity were observed when compared to VIIRS and MODIS, however these were in part attributed to lower spatial resolution. Hotspots using other sensors and/or algorithms are validated to varying degrees, however peer-reviewed publications containing validations studies over Australia are not available.

Sheet 2 Technical Characteristics

Sheet 2.1 Product Spatial Details

<table>
<tr><td>Frequency</td><td colspan="3">Based on available satellite data</td></tr>
<tr><td>Temporal Extent</td><td colspan="3">MODIS: from 27 August 2002
AVHRR: from 19 October 2006
VIIRS: from 21 February 2014
AHI: from 1 July 2015</td></tr>
<tr><td rowspan="6">Spatial Extent</td><td rowspan="4">Geographic Coverage</td><td>Min latitude</td><td>-45</td></tr>
<tr><td>Min longitude</td><td>105</td></tr>
<tr><td>Max latitude</td><td>8</td></tr>
<tr><td>Max longitude</td><td>180</td></tr>
<tr><td>Projection</td><td colspan="2">EPSG:4326 (https://epsg.io/4326)</td></tr>
<tr><td>Accuracy</td><td colspan="2">• The Hotspot location on any map (no matter how detailed) is only accurate at best to ± 1.5 km
– AVHRR: ± 1 km
– MODIS: ± 1 km
– VIIRS: ± 0.375 km
– AHI: ± 2 km
• The Hotspot algorithms show different pixel locations on source satellite imagery:
– All Landgate Hotspots are located within the centre of the pixel (VIIRS, AVHRR, MODIS, AHI).
– Hotspots are calculated from mapped space where the imagery is first reprojected to determine line and pixel of the Hotspot, with latitude and longitude calculated based on the top-left of the image.
– VIIRS (AFIMG, AFMOD): Hotspot points are located within the centre of the pixel.
– MODIS (MOD14): Hotspots are located in the north-west corner of the pixel.
– AHI (RMIT & BNHCRC) Hotspots are located within the centre of the pixel, noting the native Himawari-9 coordinate system which uses an irregular grid is used for processing hotspots.</td></tr>
</table>

		• The geolocation of the imagery is linked to the nominal position of the satellite. Satellites like MODIS (Terra) have inbuilt Global Positioning System (GPS) and are more accurately geolocated than NOAA AVHRR. • There are known spurious Hotspots associated with poorly calibrated SDR input data (VIIRS-AFIMG) (Schroeder and Giglio, 2018). This may be seen as Hotspots occurring as a line across the map. These inaccurate Hotspots are routinely manually removed from the Hotspots map and database as part of the operational maintenance of the Hotspots system, however some may remain.

Sheet 2.2 Attributes

The attributes and metadata included with each Hotspot vary according to the access mechanism used to interact with the Hotspot information. E.g., the Hotspots portal contains a subset of these attributes, while the Geoscience Australia Historic Hotspot database (the Historic database) contains the full metadata record for each Hotspot.

Hotspot Attributes	**ID**	Numeric ID assigned to the Hotspot
	Satellite	Name of the satellite platform that is carrying the sensor used to acquire the satellite data for hotspots calculation (e.g., Terra, Aqua, Suomi NPP, NOAA-20)
	Satellite_nssdc_id	National Space Science Data Centre (NSSDC) uniquesatellite number (*http://nssdc.gsfc.nasa.gov/nmc/*)
	Satellite_operating_agency	Name of the agency providing the satellite data (e.g., NASA)
	Sensor	Name of the sensor used to detect the Hotspot (e.g., MODIS, VIIRS, AVHRR, AHI)
	Orbit	The orbit number is determined using the information provided in the NORAD Two Line Element (TLE) file(s).The TLE file provides reference information foran "epoch" orbit that allows the current orbit to be calculated using the acquisition information. A value of -1 indicates the orbit is not reported.
	Start_dt	Start date and time (in UTC) of the satellite pass acquisition
	Stop_dt	Stop date and time (in UTC) of the satellite pass acquisition. Note that Himawari-9, NOAA-20, and Suomi NPP do not have Stop_dt information.
	Filename	File name that the Hotspot is contained in and uses the following format: satellite_dateUTC_Hotspot.txt
	Process_dt	Date and time (in UTC) that the Hotspot was processed (file creation time)
	Process_algorithm	The name of the algorithm used to producete Hotspot (e.g., MOD14, AFIMG, BRIGHT AHI).
	Process_algorithm_version	Algorithm version number used to produce the Hotspot
	Product	Name of the product within the database (e.g., LANDGATE_AHI, MOD14)
	Load_dt	Date and time (in UTC) that the Hotspot was loaded into the database

Hotspot Attributes	**Latitude**	Hotspot latitude is based on WGS84 (º). Units: signed decimal degrees Format: -dd.ddd 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 is based on WGS84 (º). Units: signed decimal degrees Format: ddd.ddd 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	To detect the presence of a Hotspot, aset of detection criteria has been developed. These criteria (which differ for day and night observations) are based on: • the absolute detection of a fire (when thefire strength is sufficient to be detected) • detection relative to the difference between the fire pixel and its background temperature (to account for the variability of surface temperature and reflection by sunlight) (Justice *et al.,* 2006). • For BRIGHT Hotspots, the 3.9µm brightness temperature as defined by the Himawari-9 satellite. Units: degrees Kelvin Format: nnn.n

	Power[2]	• AVHRR, VIIRS, AHI and MODIS before April 2008
		  – Do not have a Power attribute
		  – Null values or -1
		• MODIS after April 2008
		  – Estimate of Fire Radiated Power (FRP) of Hotspot pixel (based on Justice *et al*., 2006).
		• BRIGHT
		  – Estimate of FRP of Hotspot pixel based on Wooster *et al.,* (2003) (Engel *et al.*, (2022)).
		  – No FRP value is indicated with -999.
		
		Units: Megawatt (MW)
		Format: *nnn.n*

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

		Valid range: ≥ 0.0 (maximum observed value 1900.0)
	Confidence	The Confidence attribute is intended to help users to gauge the quality of individual fire pixels within the fire mask. GA displays and provides all Hotspots, regardless of confidence. Users can choose to filter on the confidence attribute, according to their use case. • MODIS – MOD14 Fire Detection Algorithm indication of the confidence that a Hotspot is a fire (Giglio *et al*., 2003): ○ 0-30% "low" ○ 30-80% "nominal" ○ 80-100% "high" • AVHRR and AHI – No Confidence is given as the algorithm does not calculate this attribute – The Hotspots portal includes a default confidence value of 50% • BRIGHT AHI – Percentage confidence for each detected Hotspot (0-100%) • VIIRS – Percentage confidence for each detected Hotspot (0-100%) Units: none (scalar value) Format: nnn Valid range: 0 – 100 Null values: Null or -1
	Datetime	Time of acquisition for the data in which the Hotspot was detected (UTC). This is determined based on the start and end time of the acquisition. For the current satellites the level of accuracy should be of the order of 5 mins. Format: YYYY-MM-DDThh:mm:ssZ (YYYY-MM-DDT Local time) where YYYY-MM-DD is the date, and Thh:mm:ssZ is the time in UTC There are different rules for observation timesfor different satellites: • Aqua and Terra (MODIS): the observation time is an estimated value based on the location of the Hotspot within the satellite

		acquisition and time range of the acquisition. • Suomi 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-9 (AHI): the observation time is an estimated value based on the location of the Hotspot within the satellite acquisition and time range of the acquisition.
	Australian_state	State that the Hotspot was captured in (e.g., NSW, ACT, WA, NT, VIC, TAS, QLD, SA).
	Hours_since_hotspot	Hours since hotspot detection – only provided with web service access, and only correct at time of access.
	Accuracy	Accuracy of the Hotspot detection based on the resolution of the satellite used.

Hotspots – Data Licence

Sheet 3 Licensing and Attribution

Licence	Creative Commons 4.0 Attribution International license (CC BY 4.0 International).
Data attribution	**Landgate** hotspot data attribution: • © Western Australia Land Information Authority (Landgate) Attribution for use of **BRIGHT hotspots** location and date/time data. • Engel, C.B., Jones, S.D., Reinke, K.J., (2021) Real-time detection of daytime and night-time fire hotspots from geostationary satellites. *Remote Sensing* **13**(9), p.1627. • Engel, C.B., Jones, S.D., Reinke, K.J., (2021) A seasonal-window ensemble-based thresholding technique used to detect active fires in geostationary remotely sensed data. *IEEE Transactions on Geoscience and Remote Sensing* **59**(6), pp.4947-4956. Attribution for use of **BRIGHT hotspots FRP** data. • Engel, C.B., Jones, S.D. and Reinke, K.J., (2022) Fire Radiative Power (FRP) Values for Biogeographical Region and Individual Geostationary HHMMSS Threshold (BRIGHT) Hotspots Derived from the Advanced Himawari Imager (AHI). *Remote Sensing* **14**(11), p.2540.
Disclaimer	The information displayed on DEA Hotspots (the “Service”) is for general informational purposes only, and is not intended to provide any commercial, financial, or legal advice. DEA Hotspots is not to be used for safety of life decisions. Please see the GA website for the full disclaimer notice.
History	To read about GA’s history of involvement in DEA Hotspots, see Reddy (2005), Hudson and Mueller (2009).

GA Historic Hotspot database

Hotspot pixels are identified and extracted from the satellite image into the GA Historic Hotspot database (the Historic database). The Historic database provides a complete and on-going record of Geoscience Australia's Hotspots product.

The Historic database is available via AWS in CSV, GeoJSON and Geography Markup Language (GML) formats.

The GA Historic Hotspots database is available at https://hotspots.dea.ga.gov.au/files/historic

The Historic database is broken up into three separate files. The table below details what data is contained within each file.

Note that the files are very large and are currently unable to be opened with standard tools like excel or Google Earth as they contain millions of records. Work is underway to make these files more user friendly. In the meantime, these files need to be accessed programmatically e.g., using Python.

Sheet 4 GA Historic Hotspot database

File name	**ahiwfabba-all-csv.zip** **ahiwfabba-all-geojson.zip**	
Satellites / Sensor	Himawari-8 / AHI	
Algorithm / **Data date range**	WFABBA v.6.5.010g (Wild Fire Automated Biomass Burning Algorithm)	1/7/15 – 28/5/20
Citations	Dozier 1981; McNamara *et al*., 2004; Schmidt and Prins, 2003	
Date range (all)	1/7/2015 – 28/5/2020	
Number of entries	15,202,290	
File name	**all-data-csv.zip** **all-data-geojson.zip** **all-data-gml.zip**	
Satellites / Sensor	Himawari-8 / AHI Himawari-9 / AHI Aqua / MODIS Terra / MODIS NOAA-17 / AVHRR NOAA-18 / AVHRR NOAA-19 / AVHRR NOAA-20 / VIIRS Suomi NPP / VIIRS	
Algorithm / **Data date range**	Himawari-8 AHI	
	• Landgate AHI v.1.0.0	29/5/20 – 13/12/22
	• SRSS AHI v.1.0.0	27/9/19 – 29/5/20
	Himawari-9 AHI	
	• BRIGHT AHI v.1.86	13/12/22 – present

	• Landgate AHI v.1.0.0	13/12/22 – present
	MODIS	
	• MOD14 v.5.0.1, v.6.2.1	15/10/13 – present
	• Landgate MODIS daytime v.6.2.1	30/5/20 – present
	• Landgate MODIS Nighttime v.6.2.1	30/5/20 – present
	• SRSS MODIS daytime v.6.2.1	30/8/19 – 29/5/20
	• SRSS MODIS Nighttime v.6.2.1	30/8/19 – 29/5/20
	• nan* v.4.2.0, v.4.3.1, v.5.0.1, v.6.2.1	27/9/02 – present
	NOAA-17 AVHRR	
	• nan* v.1.0.0	19/10/06 – 28/8/11
	NOAA-18 AVHRR	
	• nan* v.1.0.0	19/10/06 – 24/4/14
	NOAA-19 AVHRR	
	• Landgate AVHRR v.1.0.0	29/5/20 – present
	• SRSS AVHRR v.1.0.0	29/9/19 – 28/5/20
	• nan* v.1.0.0	29/3/10 – 25/4/14
	NOAA-20 VIIRS	
	• AFIMG v.6	15/10/19 – present
	• AFMOD v.6	15/10/19 – present
	• Landgate Daytime VIIRS algorithm v.6	30/5/20 – present
	• Landgate Nighttime VIIRS algorithm v.6	30/5/20 – present
	• SRSS Daytime VIIRS algorithm v.6	15/10/19 – 29/5/20
	• SRSS Nighttime VIIRS algorithm v.6	15/10/19 – 29/5/20
	Suomi NPP VIIRS	
	• AFIMG v.6	30/8/19 – present
	• AFMOD v.6	30/8/19 – present
	• Landgate Daytime VIIRS algorithm v.6	30/5/20 – present
	• Landgate Nighttime VIIRS algorithm v.6	30/5/20 – present
	• SRSS Daytime VIIRS algorithm v.6	29/9/19 – 29/5/20
	• SRSS Nighttime VIIRS algorithm v.6	29/9/19 – 29/5/20
	• VCM 1.O.000.002 v.6	3/5/17 – 2/2/22
	• VIIRS (AER) v.6	21/2/14 – 14/9/17
	* some of the earlier data entries are incomplete, including missing the algorithm used to generate the hotspot. The algorithm field has the 'nan' placeholder used instead.	
Citations	VIIRS (AER): Gilio, *et al.*, 2003b, Baker *et al.*, 2011 See also Sheet 1	
Date range (all)	27 August 2002 – present	
Number of entries	32,370,816 (as of 17/07/23)	

File name	**avhrr-ga-all-csv.zip** **avhrr-ga-all-geojson.zip**
Satellites / Sensor	NOAA-18 / AVHRR NOAA-19 / AVHRR

Algorithm / Data date range	GA AVHRR v.1.0.0	8/7/14 – 17/12/22
Date range (all)	8 July 2014 – 17 December 2022	
Number of entries	1,909,483	

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Glossary

AFIMG	VIIRS Imager Resolution (375m) NOAA-20 and Suomi NPP Sensor Data Records
AFMOD	VIIRS Moderate Resolution (750m) NOAA-20 and Suomi NPP Sensor Data Records
Aqua	NASA satellite collecting data on Earth's water cycle (USA)
AER	Atmospheric and Environmental Research
AHI	Advanced Himawari Imager (JMA)
ASTER	Advanced Space-borne Thermal Emission and Reflectance Radiometer
ATMS	Advanced Technology Microwave Sounder
AVHRR	Advanced Very High Resolution Radiometer
AWS	Amazon Web Services
BNHCRC	Bushfires and Natural Hazards Cooperative Research Centre
BRIGHT	Biogeographical Region and Individual Geostationary HHMMSS Threshold algorithm
CrIS	Cross-track Infrared Sounder
CSPP	Community Satellite Processing Package
CSV	Comma separated values
DEA	Digital Earth Australia (GA)
FRP	Fire Radiated Power
GA	Geoscience Australia
GeoJSON	Geospatial data interchange format based on JavaScript Object Notation
GeoRSS	Geographically Encoded Objects for Rich Site Summary (notification service)
GML	Geography Markup Language
GPS	Global Positioning System
IMAPP	Algorithm that produces MODIS Level 2 Cloudmask, Cloudtop Properties, Cloud Phase, Atmospheric Profiles, and Aerosol https://cimss.ssec.wisc.edu/imapp/
JMA	Japan Meteorological Agency
KML	Keyhole Markup Language
MODIS	MODerate resolution Imaging Spectroradiometer (NASA)
MOD14	MODIS Terra Thermal Anomalies product
MYD14	MODIS Aqua Thermal Anomalies product

MW	Megawatts
NASA	National Aeronautics and Space Administration (USA)
NOAA	National Oceanic and Atmospheric Administration (USA)
NORAD	North American Aerospace Defense Command (USA)
NPP	National Polar-orbiting Partnership (USA)
OGC	Open Geospatial Consortium
RMIT	Royal Melbourne Institute of Technology
RSS	Rich Site Summary (notification service)
SDR	Sensor Data Record
SPA	Science Processing Algorithm
SRSS	Satellite Remote Sensing Services (former name for Landgate Imagery team)
Suomi NPP	Suomi National Polar-orbiting Partnership
Terra	NASA satellite collecting data on Earth's land processes (USA)
TLE	Two Line Element
UTC	Coordinated Universal Time or Universal Time Coordinated
VIIRS	Visible Infrared Imaging Radiometer Suite
WFABBA	Wild Fire Automated Biomass Burning Algorithm
WFS	Web Feature Service
WGS	World Geodetic System
WMS	Web Map Service
XML	Extensible Mark-up Language