

Online remote sensing tools for UK wildfires: Step-by-Step guide

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Table 1: List of 2020 UK wildfires observable in satellite imagery.

Wildfire	Date	Latitude	Longitude	Burnt Area (ha)
Bursdon	23/03/2020	50.95	-4.47	25
Bodrithy	26/03/2020	50.17	-5.58	80
Glanaman	26/03/2020	51.8	-3.83	658
Bolventor	27/03/2020	50.57	-4.51	28
Newbridge	27/03/2020	50.13	-5.622	20
Glanaman2	29/03/2020	51.8	-3.82	583
Glanaman3	29/03/2020	51.8	-3.76	495
Brown Willy	30/03/2020	50.61	-4.61	233
Maesteg fires	01/04/2020	51.6	-3.66	100
Dowlais	11/04/2020	51.81	-3.39	1447
Mountfield	15/04/2020	54.65	-7.13	220
Rhiwderin	15/04/2020	51.62	-3.15	105
Loch Garve	18/04/2020	57.59	-4.67	304
Loch Ness	19/04/2020	57.4	-4.42	34
Worsthorne	19/04/2020	53.8	-2.13	95
Armoy	21/04/2020	55.12	-6.27	332
Gwaun Hepste	21/04/2020	51.8	-3.54	323
Old Kilpatrick	21/04/2020	55.95	-4.43	127
Llangynog	22/04/2020	52.83	-3.41	152
Marsden wood	23/04/2020	53.59	-1.91	170
Castle Douglas	24/04/2020	54.98	-4.17	1669
Torside	24/04/2020	53.51	-1.93	93
Gower	25/04/2020	51.6	-4.16	24
Mourne Mountains	25/04/2020	54.16	-6.01	144
Loch Kishorn	04/05/2020	57.38	-5.58	402
Balloch	05/05/2020	55.22	-4.55	187
Crynant	05/05/2020	51.77	-3.66	160
Claudy	06/05/2020	54.97	-7.15	18
Rothbury	14/05/2020	55.28	-1.96	43
Hatfield Moors	21/05/2020	53.55	-0.94	350
Sperrin	21/05/2020	54.8	-6.94	47
Waldridge Fell	22/05/2020	54.84	-1.61	6
Wareham Forest	18/05/2020	50.73	-2.16	225
Coalburn	29/05/2020	55.6	-3.9	71
Darwen Moor	30/05/2020	53.67	-2.5	450
Isle of Skye	30/05/2020	57.25	-5.75	10
Rhos	31/05/2020	51.98	-4.35	56
Thursley Common	31/05/2020	51.16	-0.71	167
Cabra	01/06/2020	54.2	-6.02	10
Chobham Common	07/08/2020	51.38	-0.62	86
Ringwood Forest	11/08/2020	50.87	-1.84	7
Isle of Harris	12/02/2021	57.90	-6.91	200

I. NASA's Worldview

1. Go to this link: <https://worldview.earthdata.nasa.gov/>
2. In your own time, you can explore the various layers and visualisations, but for our purposes, we would like to see active fire data. To do this, close the intro screen and click the '+layers' button. Search for 'fire'. There are a few options here, but the most useful are the following:
 - Fires and Thermal Anomalies (Day and Night) Terra and Aqua / MODIS
 - Fires and Thermal Anomalies (Day and Night, 375 m) Suomi NPP / VIIRS
 - Fires and Thermal Anomalies (Day and Night, 375 m) NOAA-20 / VIIRS
 - MODIS has a spatial resolution of 500 m; VIIRS has a spatial resolution of 375 m. Both sensors image the planet twice per day (one daytime observation, one night-time observation)
 - Terra / MODIS overpass is at ~11:00 and 23:00 UTC
 - Aqua / MODIS overpass is at ~14:00 and 02:00 UTC
 - NOAA-20 / VIIRS overpass is at ~12:55 and 00:55 UTC
 - Suomi NPP / VIIRS overpass is at ~13:30 and 01:30 UTC
 - Imagery can usually be found on NASA Worldview around 2–3 hours after acquisition.
3. To speed things up, you can use [this link](#) that includes all of the layers that are useful for wildfires.
4. Latitude and longitude of your mouse cursor can be viewed in the bottom-right of the window, next to the scale bar. You will need to use this to find the 2020 wildfires.
5. Let's take a look at the **Balloch wildfire** (55.22°N 4.55°W), which peaked on 5 May 2020. Change the date in the bottom-left of the window and navigate to the wildfire location. Make sure the wildfire layers are visible by toggling the 'eye' visibility button. Toggle the base layer 'Corrected Reflectance (Bands 7-2-1)' to see what extra information you can glean from this layer.
6. Let's take a look at the **Hatfield Moors wildfire** (53.55°N 0.94°W), which peaked on 21 May 2020. There were fire detections over 5 days, so take a look at the days either side of 21 May 2020.
7. Finally, let's take a look at the **Castle Douglas wildfire** (54.98°N 4.17°W), which peaked on 24 April 2020. This was one of the largest wildfires of 2020. You can clearly see the active fire detections, which may be used to deduce the location of the fire through the day and night.
 - Different platforms overpass at different times of the day (see Step 2), you can visualise each sensor and the day and night wildfire detections separately (search the wildfire layers for these options).
8. Sticking with the Castle Douglas wildfire, skip ahead one day to 25 April 2020 and toggle on the base layer 'Corrected Reflectance (Bands 7-2-1)'. This layer is good for visualising dead vegetation, as a result, you can clearly see the burn scar in this layer compared with the 'true colour' base layer where the burn scar is less visible.
9. If you want to export the imagery to a GIS/Google Earth, use the snapshot (camera) button (top-right of the window). Select the area of interest, resolution and format of the imagery. For GIS applications such as ArcGIS or QGIS use 'GeoTIFF', for Google Earth use 'KMZ'. If you just want a basic image file, use JPG or PNG. Hit 'download' and you will receive the high quality image/GIS file.

Conclusions:

- Earth Explorer is good for a quick view of automated hotspot detections for fires >100 ha. The hotspots are not particularly useful for delineating fire perimeters unless the fire is >500 ha.
- Post-fire burnt area can be evaluated using Earth Explorer, but only useful for large fires.

II. EU Sentinel Hub

We are going to use the EU's Sentinel Hub to visualise Sentinel-2 satellite imagery. Sentinel-2's sensors have a much higher spatial resolution than NASA's MODIS and VIIRS sensors. This allows us to visualise UK wildfires in far more detail. However, with higher spatial resolution comes lower observation frequency (temporal resolution), with imagery captured once every ~4 days.

- Visible (true colour) imagery has a spatial resolution of 10 m.
- Thermal imagery (useful for looking at active fire fronts) has a spatial resolution of 20 m.
- Observation frequency is around one overpass every ~4 days.
- Overpass time is shortly before midday UTC for the UK.
- Imagery can usually be viewed around 4–5 hours after acquisition.

If you are expecting wildfires (e.g. weather warnings/high FSI/FFMC etc.) or if you have an ongoing wildfire incident, you can check whether Sentinel-2 is going to overpass your region using the Sentinel-2 Acquisition Plans:

1. Head to the following link: <https://sentinel.esa.int/web/sentinel/missions/sentinel-2/acquisition-plans>
2. Download the acquisition plans that span the current date for both Sentinel-2A and Sentinel-2B.
3. Open the acquisition plan in Google Earth (you can download Google Earth Pro for free [from here](#)).
4. Navigate to the UK in Google Earth and use the time slider (top left of the map) to visualise the overpass swaths.
5. Click on one of the swaths to find the specific overpass date and time (e.g. 2020-12-12T11:14:45).

Now let's take a look at some Sentinel-2 imagery from the 2020 UK wildfires:

1. Here is a link to the Sentinel-hub EO browser: <https://apps.sentinel-hub.com/eo-browser/>
2. For today, please use [this link](#)
3. As you can see, for any given day, Sentinel-2 only images narrow swaths of the UK or may miss the UK altogether.
4. Let's take a look at the **Balloch wildfire** (55.22°N 4.55°W), which peaked on 5 May 2020. Use the 'Go to Place' search bar (top-right of window) to type in the co-ordinates (55.22, -4.55) and hit search. Change the date to 2020-05-05 (5 May 2020). Zoom in, you may need to re-search for the location to centre over the wildfire location once zoomed in.
5. You should now be able to see this moorland fire, with a distinguishable burnt area and a smoke plume. If you can't find it for some reason, use [this link](#). This image is composed of red, green, and blue light, like a regular 'true colour' photograph.
6. Like the NASA satellites, Sentinel-2 is equipped with sensors that can image other wavelengths of light. Click on the 'False color' visualisation button in the menu on the left of the window. This helps to emphasise where there is living and dead vegetation. We can very clearly see the burnt area now. This image can be downloaded for analysis in Google Earth to determine burnt area and perimeter length (we'll do this later in this tutorial).
7. For fires that are actively burning, we can use the satellite's thermal sensors to visualise the active fire location. Click on the 'False color (urban)' visualisation button in the menu on the left of the window. We can now clearly see the location of the active fire. We can also see the burnt area as a shade of brown compared with the live vegetation in green. The situation at the time of the image acquisition appears to show a 1.5 km flanking fire front NE of the burnt area, with isolated patches of burning in the middle of the burn, and small flanking fires on the W/SW side of the burnt area.
8. Imagery can be downloaded for sharing and/or analysis using the snapshot button (right of the window). Use the 'Basic' download for JPG/PNG images. For analysis in GIS software/Google Earth use the 'Analytical' tab. You will need an EO Browser account to use this feature (sign up for free).

9. In the 'Analytical' tab, select KMZ/PNG for the Image format, 'HIGH' for the Image resolution, keep everything else as default and click 'download'. We'll use this file later for analysing burnt area and fire perimeter.
10. Let's take a look at the **Hatfield Moors wildfire** (53.55°N 0.94°W), which peaked on 21 May 2020. Search for '53.55, -0.94' (don't forget to use the 'minus' sign for western longitudes), and select 2020-05-21 as the date. If you can't find the fire, use [this link](#).
11. Compare the 'True color' image with the 'False color (urban)' image. Here we can clearly see the value of the high resolution imagery for assisting with a complex fire on complex terrain. The false color (urban) image helps us to identify the burnt area (brown) relative to the wetlands (black) as well as the location of the many isolated fire fronts.
12. For many fires, it is likely that no active fire imagery will be captured, due to the low observation frequency and/or the presence of cloud cover. Nevertheless, the post-fire imagery should be useful for investigations and mapping. Let's take a look at the **Wareham Forest wildfire** (50.73°N 2.16°W), which peaked on 18 May 2020. Search for '50.73, -2.16', there isn't any imagery from the main day of the wildfire as the satellite didn't overpass on 18 May 2020. However, there is cloud-free imagery from before and after the fire, check out [2020-05-16](#) and [2020-05-19](#). Compare the 'False color' layers between these two dates. You can clearly see the burnt area. In the 'False color (urban)' layer you can even see an isolated fire still burning on the north side of the burnt area.
13. In your own time, explore some of the other wildfires listed in Table 1.

Extra activity (advanced):

Sentinel-hub EO Browser allows users to use 'custom' visualisations. There is a very useful custom visualisation code available for viewing wildfires [here](#). This code enables you to visualise wildfire satellite imagery as a true colour image (i.e. what our eye sees), but with the thermal imagery overlaid; a bit like a combination of the true colour layer with the false colour (urban) layer. Try it out:

1. Return to the Balloch wildfire using [this link](#).
2. Select all of the text from [this webpage](#) and copy it to your clipboard.
3. Go back to Sentinel-hub, and select 'custom' from the menu on the left. In the 'custom script', paste the text that you just copied and click 'refresh'. You should now be able to see the true colour imagery with the thermal imagery overlaid. This visualisation might be useful for non-experts, although it is important to stress that the yellow/orange colours are not real flames, but a representation of the thermal energy being released by the active fire, and are likely to show the location of flames on the ground.

Conclusions:

- Sentinel-2 imagery is potentially very useful for monitoring active fires, but you have to be lucky that the satellite overpasses while the fire is burning.
- Sentinel-2 imagery is very useful for post-fire burnt area/perimeter analysis, even for relatively small fires (>1 ha).

III. Burnt area/fire perimeter analysis in Google Earth

1. Open the KMZ file that we downloaded in Step 6 of the Sentinel-hub exercise (or any other KMZ file that you've produced in this tutorial).
2. You should now see the wildfire imagery in Google Earth.
3. Click 'Add' from the menu at the top, and then select 'polygon'. If necessary move the 'New polygon' window to the side so you can still see the burnt area.
4. Now draw a line around the apparent burnt area, once finished, go to 'altitude' tab and select 'relative to ground' from the drop down menu and type '200' into the altitude box.
5. Click on the 'measurements' tab, this is where you can view the perimeter and area statistics, select different units that suit you. Click 'ok' and the polygon will be saved.

Prometheus wildfire modelling for UK scenarios: Step-by-Step guide

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1. Go to the Prometheus website: http://www.firegrowthmodel.ca/prometheus/software_e.php
2. Download the Prometheus 6.2.4 and sample dataset (*Dogrib_V624.zip*)
3. Run '*Prometheus_6.2.4_2019_01_13.exe*'
4. Once Prometheus has been installed on your PC/laptop, run Prometheus (find it in the windows menu or by double-clicking on the Prometheus icon on your desktop)
5. Before moving on to working with UK scenarios, I strongly recommend that you go through the built-in "*Beginner's Tutorial*". To access the tutorial, click on "*Help*" and then "*Beginner's Tutorial*" from the drop-down menu. The tutorial will introduce you to how to get spatial data into Prometheus and how to create different weather and ignition scenarios (using a Canadian example). This tutorial should take 30-90 minutes depending on your IT skills.

Once familiar with the model interface, you can explore some of the UK fuel maps I have developed for use in Prometheus. Currently nine fuel maps are available for instant download*:

County	Fuel Map	British National Grid		Map Size (km)		Cell size (m)	GE link	OS link
		Easting	Northing	x	y			
Northumberland	CartingtonHill_UKH.fgm	403813	604243	2.3	1.7	5	GE	OS
Northumberland	Thrunton_UKH.fgm	402989	604537	9.0	6.7	5	GE	OS
Northumberland	Linhope_5m_UKH.fgm	389758	612313	10.7	10.6	5	GE	OS
Lancashire	Bleasdale_UKH.fgm	355700	449300	9.7	5.8	5	GE	OS
Lancashire	Anglezarke_UKH.fgm	364700	416400	3.8	2.9	5	GE	OS
Staffordshire	Hargreaves.fgm	385523	341703	1.4	1.3	5	GE	OS
Staffordshire	Hopwas.fgm	417194	305338	2.2	2.1	5	GE	OS
Staffordshire	Sherbrook_UKH.fgm	398935	317439	4.3	4.3	5	GE	OS
Denmark	Tisvilde.fgm	–	–	4.2	2.8	5	GE	MAP

*further fuel maps are available for Berkshire, Derbyshire, Durham & Darlington, Hertfordshire & Worcestershire, and Northern Ireland. If you would like to use these fuel maps, please contact Thomas Smith (t.e.l.smith@lse.ac.uk).

The speed of the model is affected by the size of these files; therefore, if you are using a less powerful PC/laptop, start by using the CartingtonHill fuel map. For a more powerful PC/laptop, you can move onto using Thrunton Woods. The Linhope example is the largest model and will only run smoothly on the PC/laptops with at least 4 - 8 GB RAM.

6. Download the fuel maps from the KCL wildfire website: <http://drtels.co.uk/drtels/blog/knowledge-exchange-portal/>
7. Be sure to save the fuel maps to a suitable location on your PC/laptop, create a folder for your fire models (e.g. *My Documents\FireModelling*)
8. Load the Cartington Hill fuel map into Prometheus (either double-click on the *CartingtonHill_UKH.fgm* file or click 'file' and then 'open...' from the drop-down menu in Prometheus and navigate to the folder containing the fire models, select *CartingtonHill_UKH* and click 'Open'.
9. This automatically loads the fuel map and elevation map. You should be presented with a view of both maps. This will also load some example weather stations with weather streams, along with some example ignitions.

10. At this stage you are welcome to run some of the existing scenarios or build your own scenarios using new ignitions and/or weather streams (go through the *Beginner's Tutorial* to learn how to do this).

The following steps deal with outputting information from Prometheus for viewing in Google Earth or a spreadsheet program (e.g. Excel). These may be useful for sharing with colleagues/land-owners/planners.

11. To export your predicted fire perimeters to view in *Google Earth*, wait until the end of one of your simulations, click '*Simulations*' and then click '*Export Fire Perimeter(s)...*' from the drop-down menu, click '*OK*', change the '*save as type*' to '*KML file*' from the drop-down menu, choose a location to save the Google Earth output, give your file a name and then click '*save*'.
12. To view fire statistics for each timestep (e.g. rate-of-spread, active fire perimeter, fire perimeter growth rate etc.), wait until the end of one of your simulations, click '*Scenario*', click '*Statistics...*' from the drop-down menu, and then click '*OK*'.