

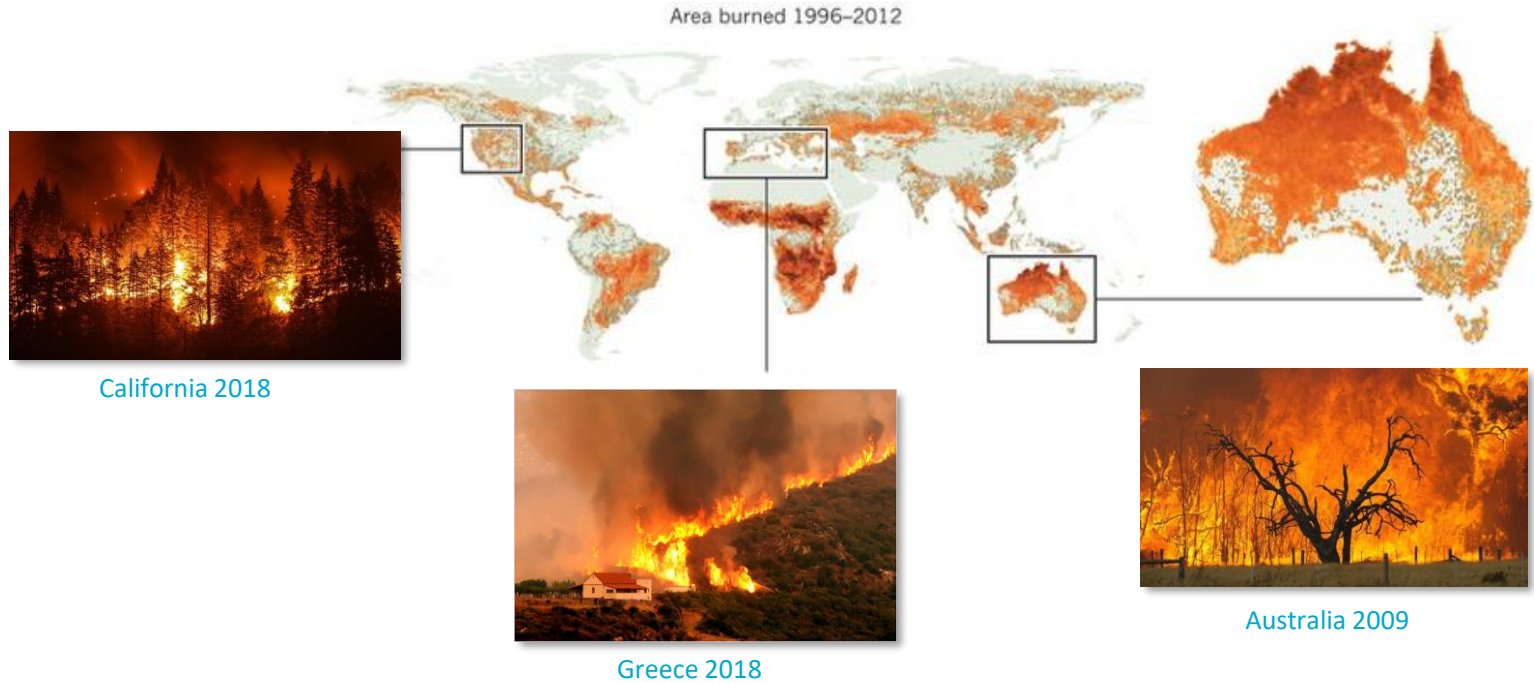
Spark

Feb 2025



Introduction

Wildfires are a devastating worldwide hazard



Source: Moritz et al. Nature 515, 58–66. *The cumulative area burned between 1996 and 2012 in millions of hectares (Mha) per mapped cell.*

Introduction

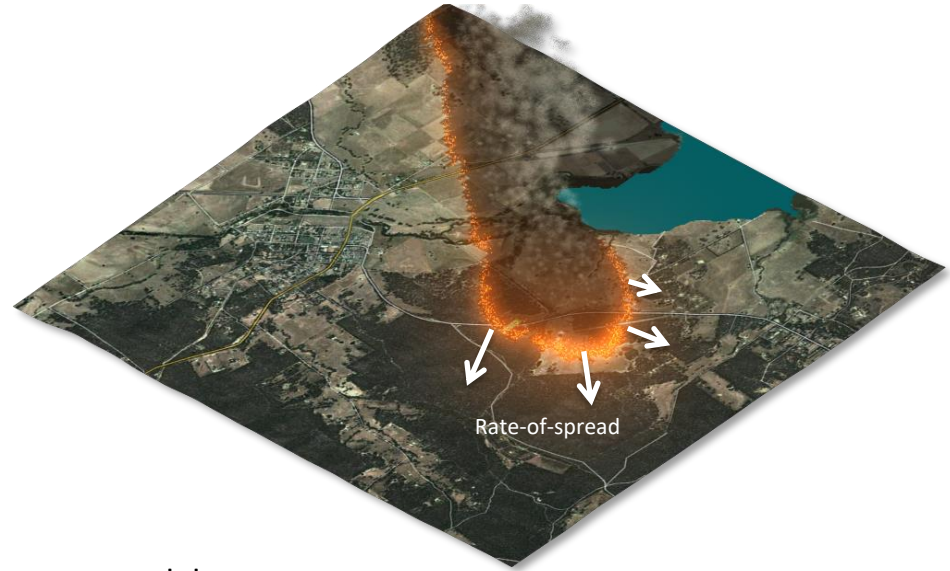
Need to simulate wildfires for risk modelling and operational management

Given:

- Ignition conditions (points, lines or areas)
- Information on the fuel and landscape
- Weather data
- Firebreaks and suppression

We need:

- Where the fire will go
- The intensity of the fire
- Heat flux on structures
- Where firebrands will land
- ...



All of these elements must be included in a computer model

Computer model must be rapid enough for operational prediction

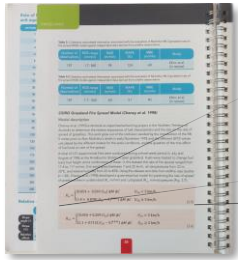
Introduction

The rate-of-spread depends on:

- The type of fuel
- The condition of the fuel (amount, moisture level, ...)

Empirical rate of spread models developed from experiments

- Mathematical function for rate-of-spread



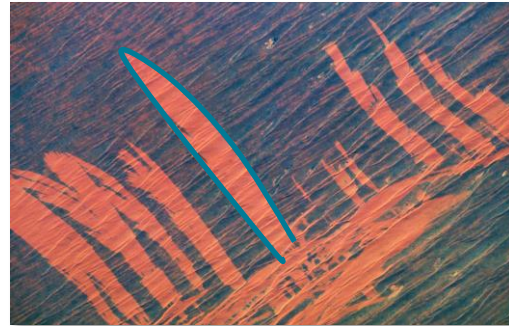
$$R_n = \begin{cases} (0.054 + 0.269 U_{10}) \phi M \phi C & U_{10} < 5 \text{ km/h} \\ (1.4 + 0.838(U_{10} - 5)^{0.844}) \phi M \phi C & U_{10} \geq 5 \text{ km/h} \end{cases} \quad [3.5]$$

Need to use many different models for fire prediction

- Each model may require different data



Eucalypt fire. Source: RMIT



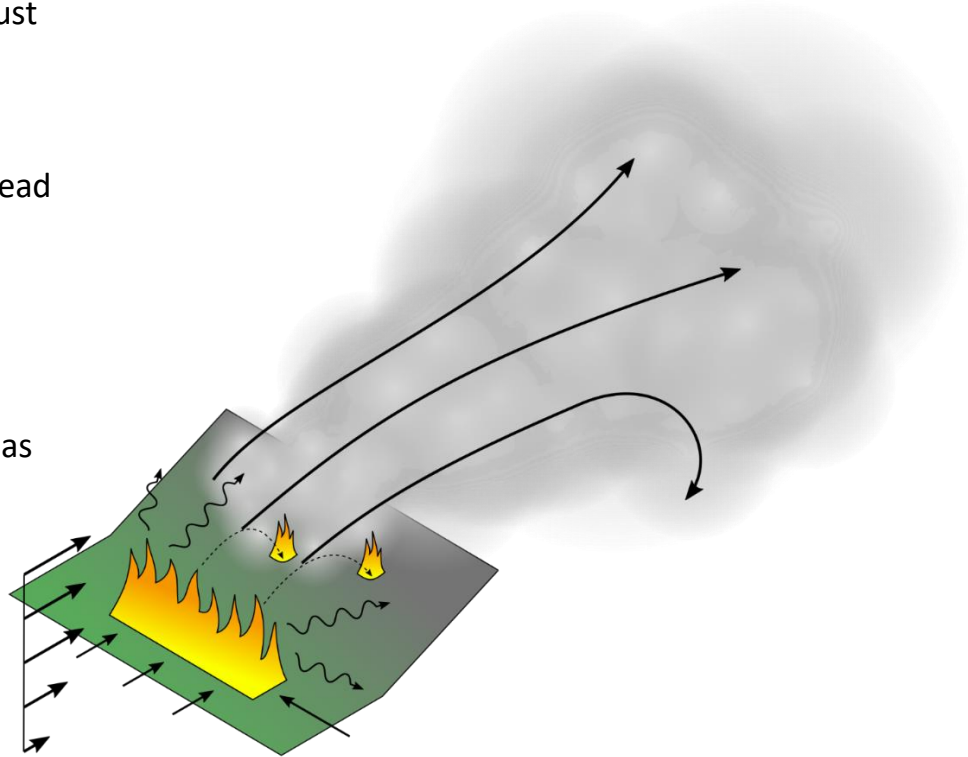
Spinifex fire. Source: NASA Earth Observatory

Introduction

In addition to the rate of spread the following must also be considered:

- Terrain - fires move faster uphill
- Local wind effects - channelling and lateral spread
- Smoke - long range effect
- 'Near-field' - fire interacts with itself
- Radiation - cause structure damage
- Firebrands - create unpredictable new fires

Ongoing worldwide research into all of these areas



Spark

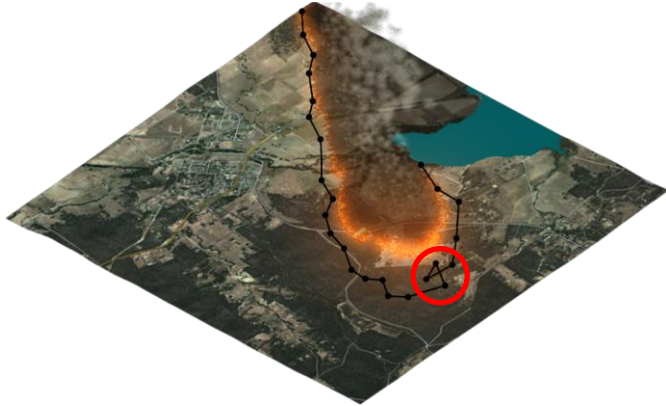
Spark is a wildfire prediction *framework*:

- Based on configurable scripts wherever possible
- Rate-of-spread based on input data – wind, fuel, terrain
- Compatibility with all common geospatial data types
- Plug-ins for firebrands, radiant heat flux, terrain, fire feedback
- Python-based for further customisation
- Web front end (SparkWeb) and server (Spark server)



Modelling

Computational wildfire models:



Front tracking

Front tracking

- Represents perimeter as line
- Very efficient to update node positions
- Need to filter nearby points
- Lines can get tangled after update/merging



Cellular

Cellular methods

- Domain is a set of cells
- Fire spreads from cell to cell
- Extremely efficient processing
- Cell geometry affects simulation

Modelling

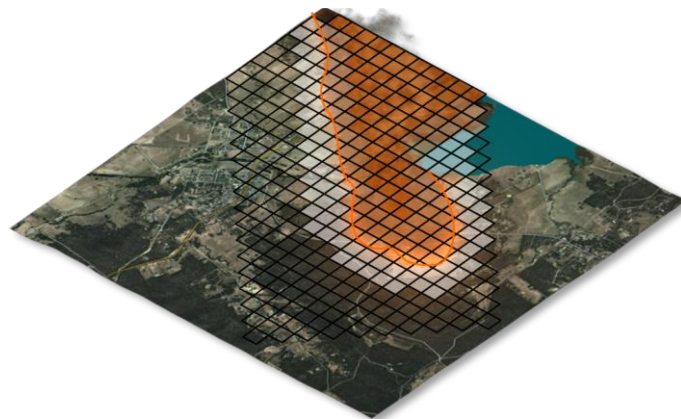
Spark model

Level set method:

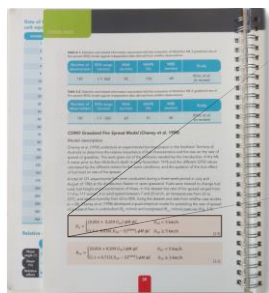
- Precise control of rate-of-spread in each cell
- Automatically handles merging fires
- Efficient and scalable on new computer hardware

Models:

- Defined using scripts, not hard-coded
- Inputs and output layers can be referenced and used
- All projections, spatial and temporal sampling transparently handled



Level set method



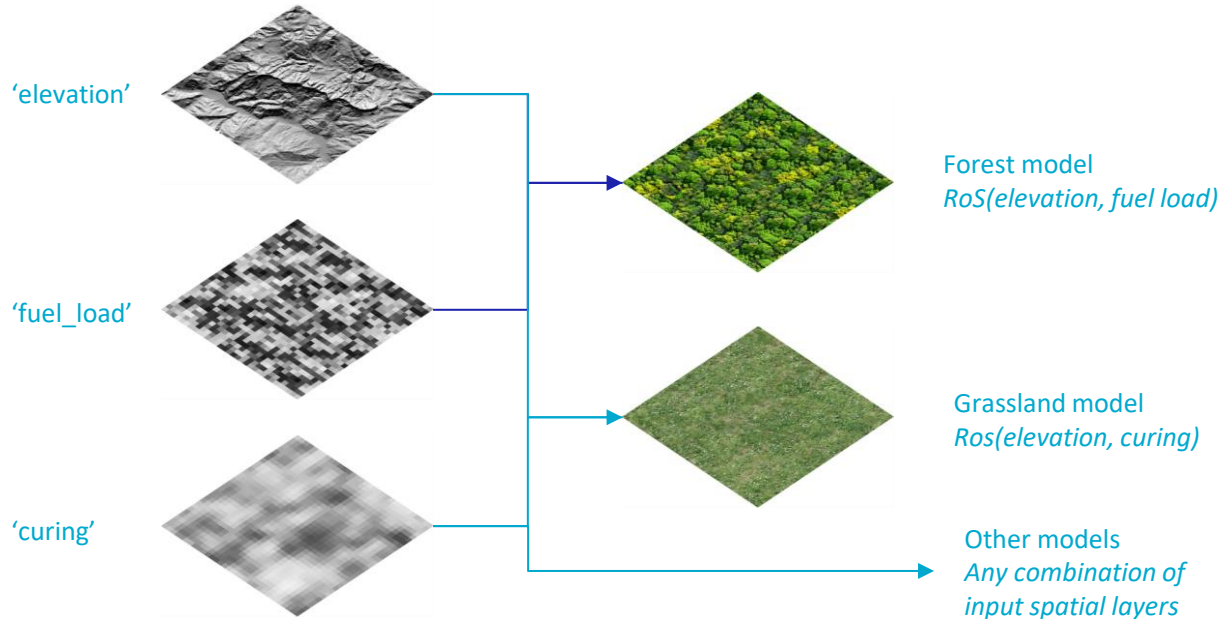
```
// Calculate spread rate from Cheney et al. (1998) (need to convert spread rate to m/s from km/hr)
if ( wind >= 5.0 )
    speed = ( 1.4 + 0.838 * pow( (wind - 5), 0.844 ) ) * moisture_coeff * curing_coeff / 3.6;
else
    speed = (0.054 + 0.269 * wind) * moisture_coeff * curing_coeff / 3.6;
```

Example script for grassland fires in Spark

Data

Any user-defined variables, layers or series can be used

- System handles spatial and temporal sampling
- Integration to support any geospatial data type



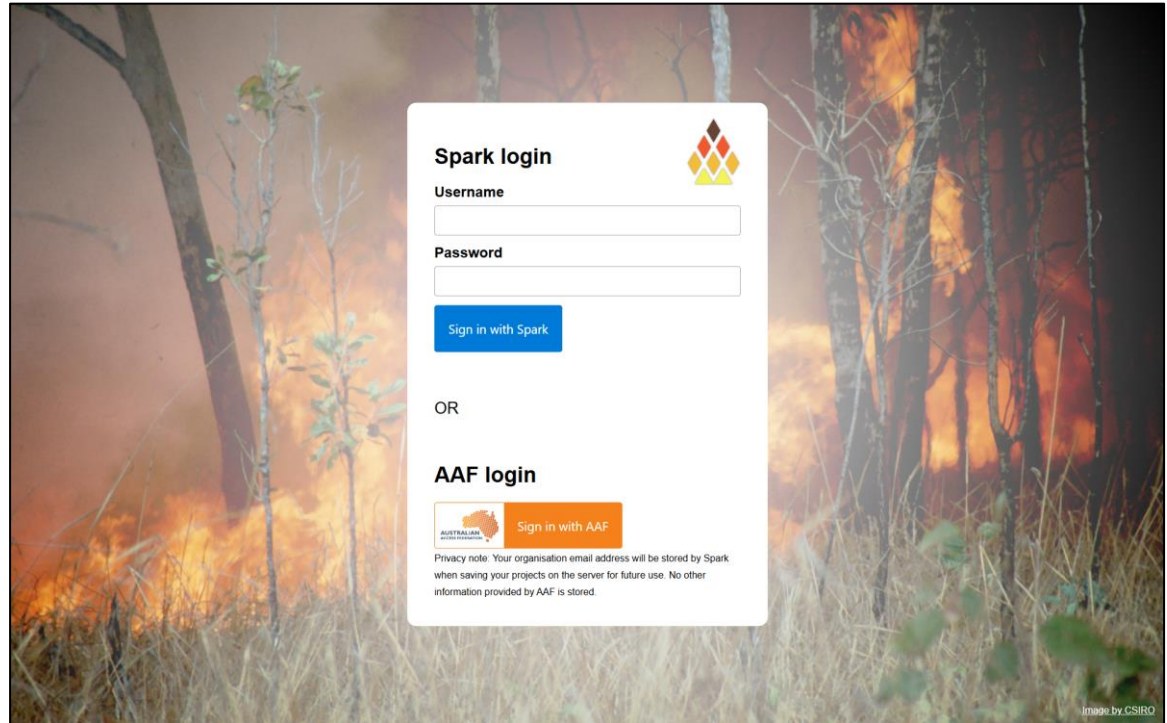
SparkWeb



SparkWeb

Usage

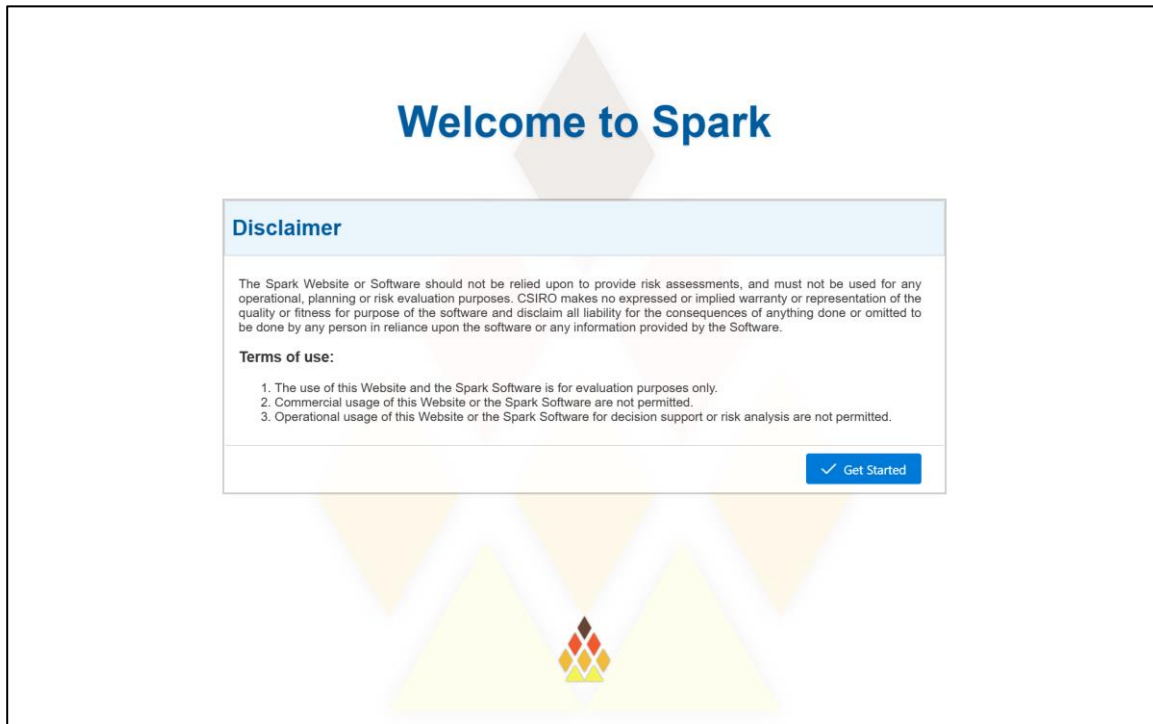
- Authentication required



SparkWeb

Usage

- Authentication required
- Terms of use



Welcome to Spark

Disclaimer

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Terms of use:

1. The use of this Website and the Spark Software is for evaluation purposes only.
2. Commercial usage of this Website or the Spark Software are not permitted.
3. Operational usage of this Website or the Spark Software for decision support or risk analysis are not permitted.

[✓ Get Started](#)

SparkWeb

Usage

- Authentication required
- Terms of use
- Create a new project



SparkWeb

Usage

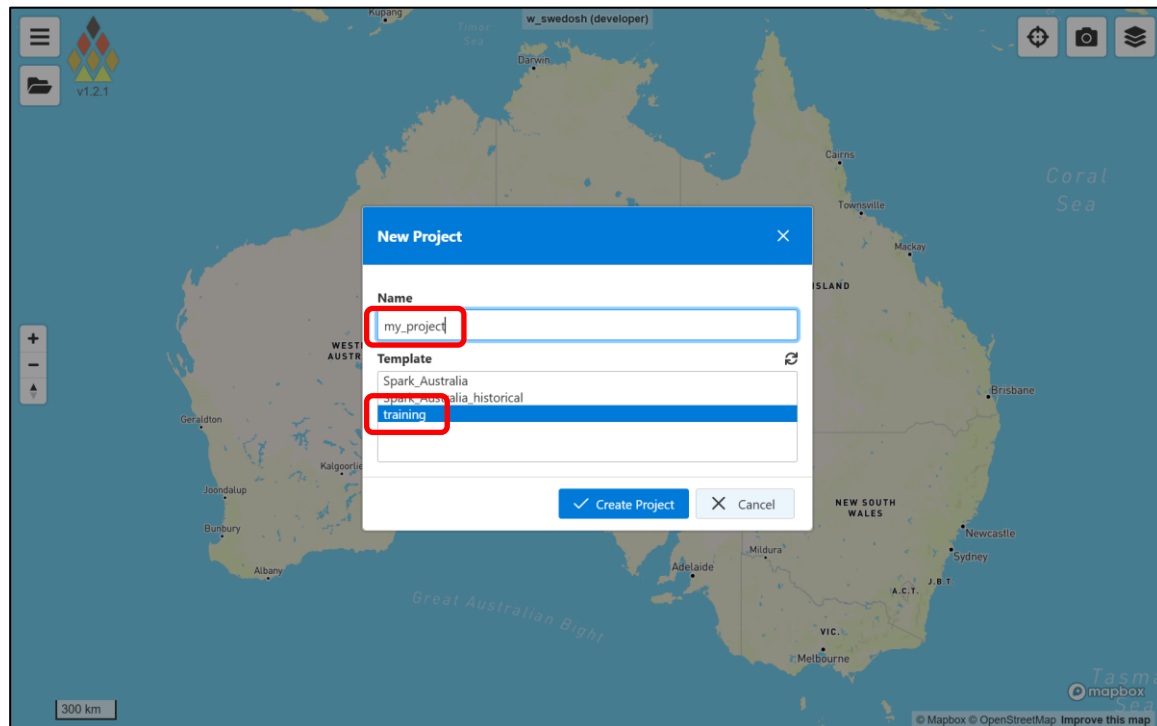
- Authentication required
- Terms of use
- Create a new project



SparkWeb

Usage

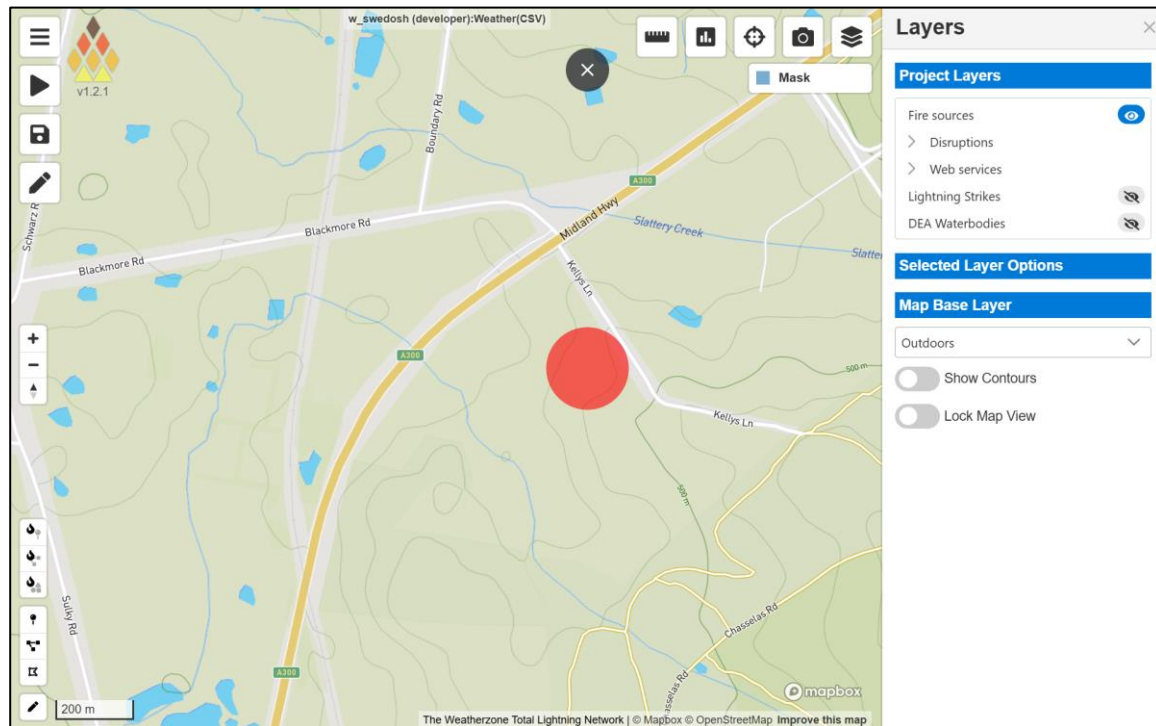
- Authentication required
- Terms of use
- Create a new project
 - *Projects must be named*
 - *Pre-populated templates*



SparkWeb

Usage

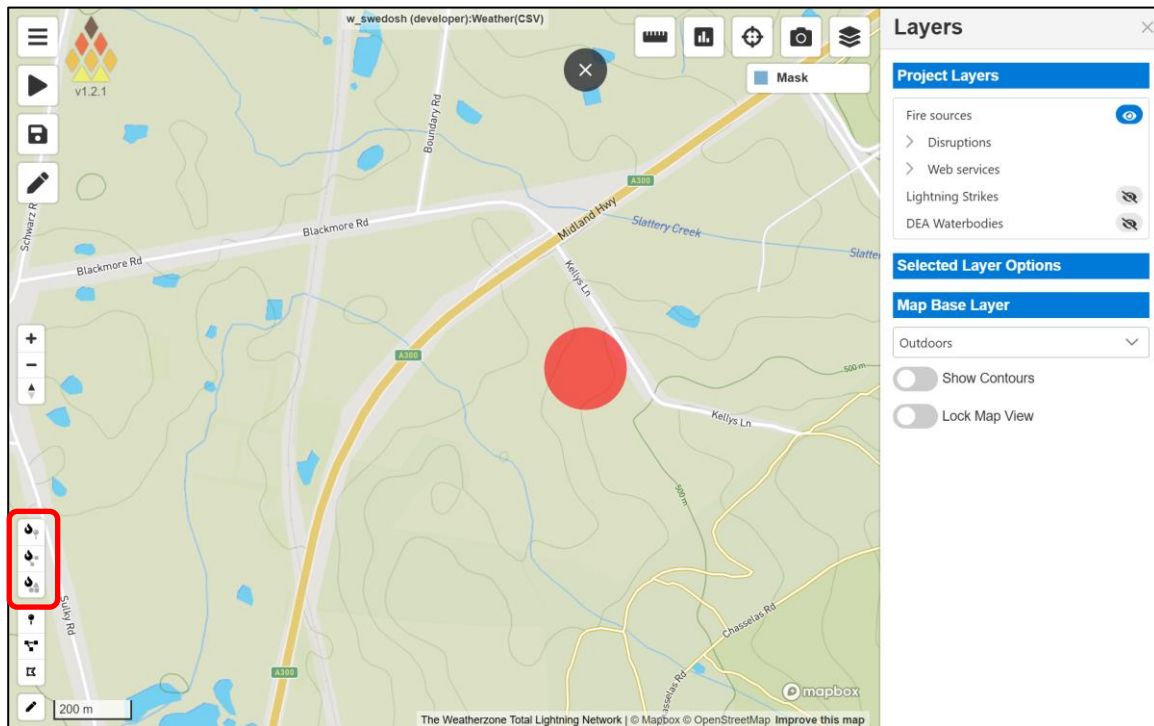
- Authentication required
- Terms of use
- Create a new project
 - *Projects must be named*
 - *Pre-populated templates*
- Layer panel on right-hand side



SparkWeb

Usage

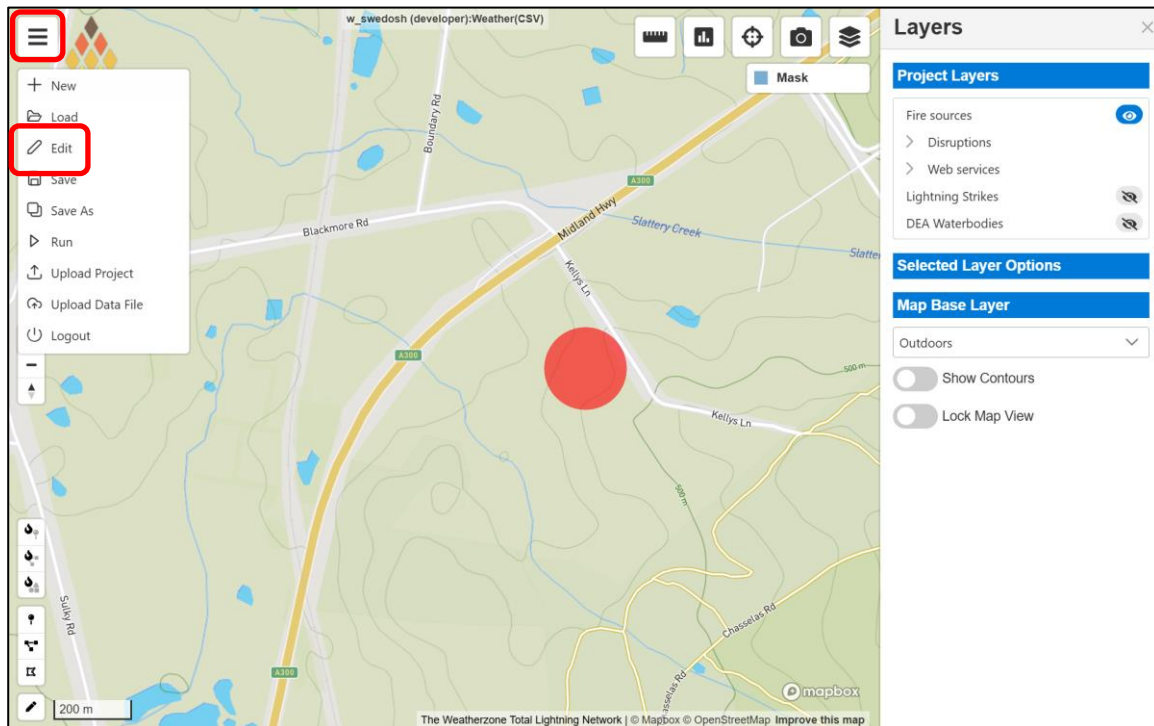
- Authentication required
- Terms of use
- Create a new project
 - *Projects must be named*
 - *Pre-populated templates*
- Layer panel on right-hand side
- Fire input conditions
 - *Tools on lower left*
 - *Point, line or polygon tool (top to bottom)*



SparkWeb

Usage





- Authentication required
- Terms of use
- Create a new project
 - *Projects must be named*
 - *Pre-populated templates*
- Layer panel on right-hand side
- Fire input conditions
 - *Tools on lower left*
- Basic simulation parameters, accessed via menu then edit (or edit pencil icon on main screen)

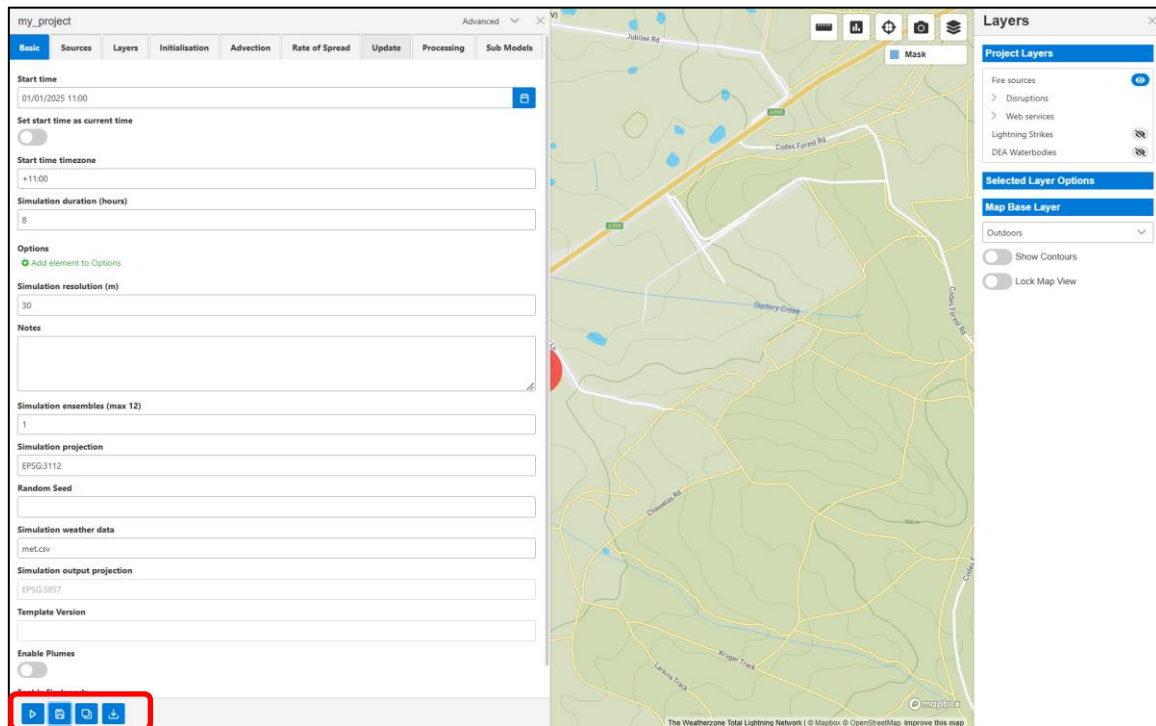


SparkWeb

Usage

- Authentication required
- Terms of use
- Create a new project
 - *Projects must be named*
 - *Pre-populated templates*
- Layer panel on right-hand side
- Fire input conditions
 - *Tools on lower left*
- Basic simulation parameters
 - *Start date and time*
 - *Time zone*
 - *Simulation duration*
 - *Simulation resolution*
- Project controls

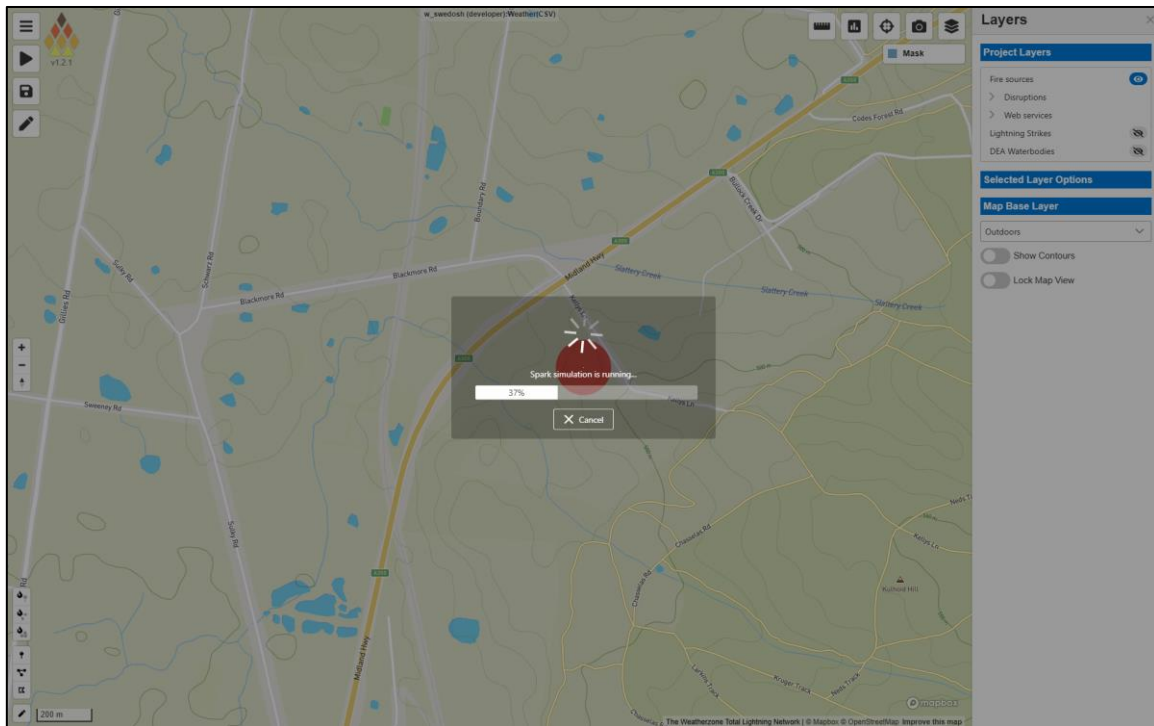
-  *Run*
-  *Save*
-  *Save as*
-  *Download*



SparkWeb

Usage

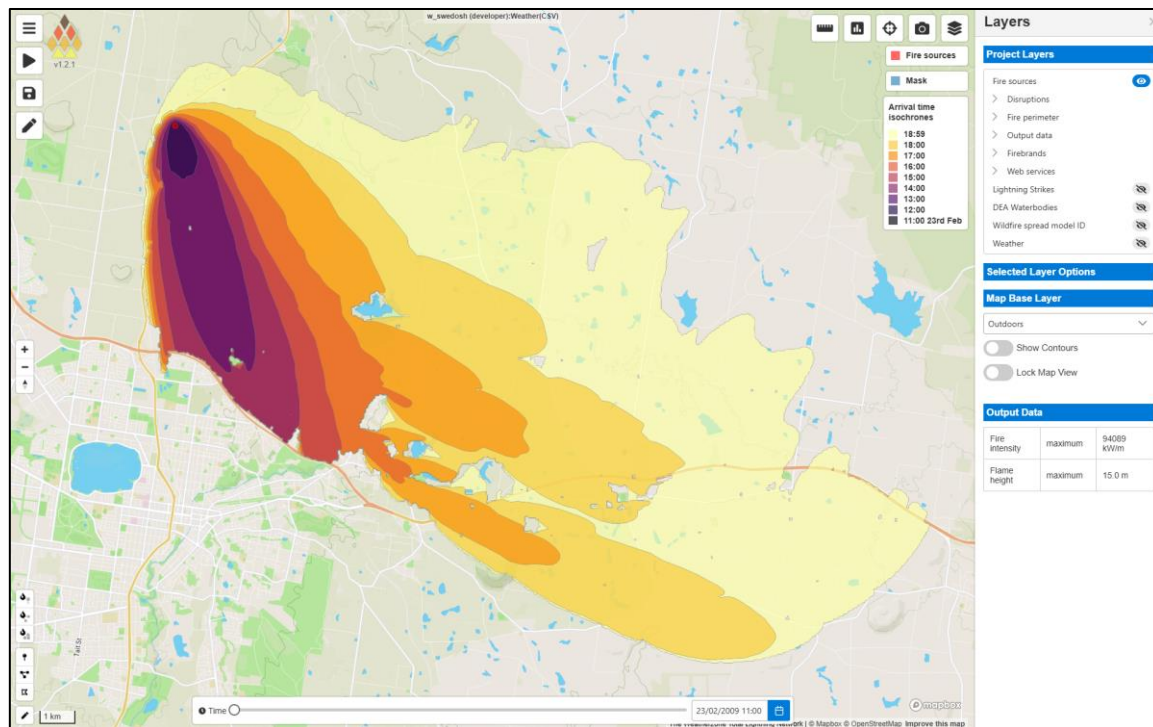
- Authentication required
- Terms of use
- Create a new project
 - *Projects must be named*
 - *Pre-populated templates*
- Layer panel on right-hand side
- Fire input conditions
 - *Tools on lower left*
- Basic simulation parameters
 - *Start date and time*
 - *Time zone*
 - *Simulation duration*
 - *Simulation resolution*
- Project controls
- Progress
 - *Shows when you press 'Run'*
 - *Any errors reported at this stage*



SparkWeb

Usage

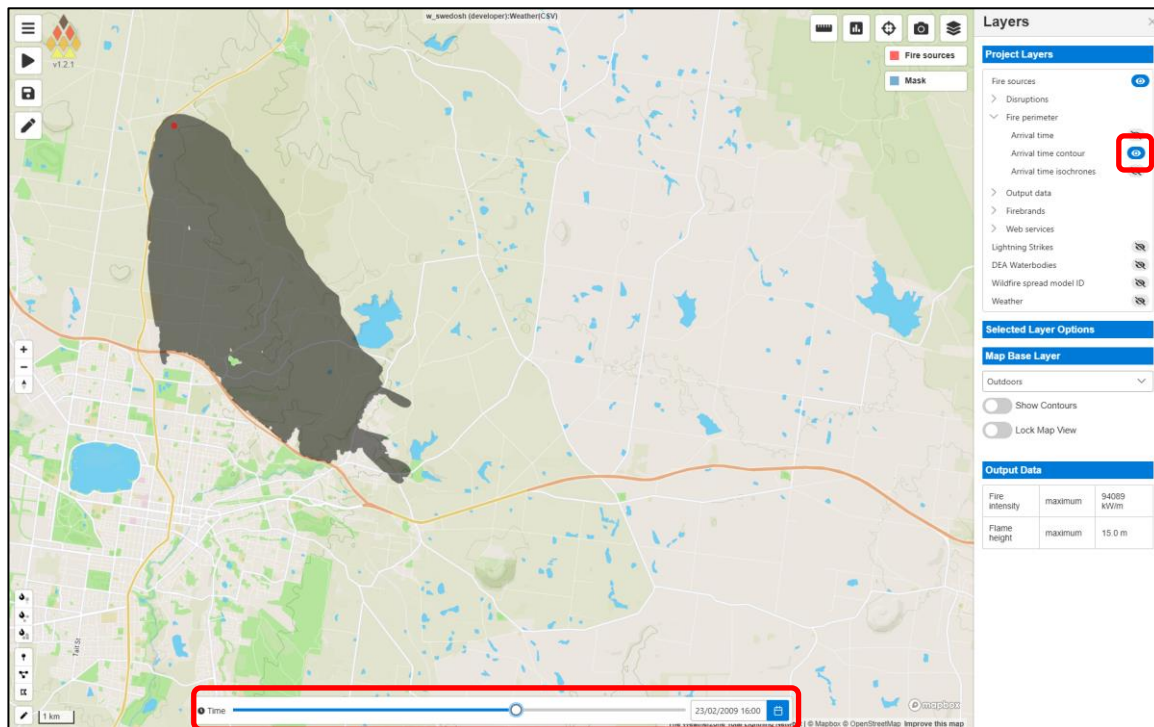
- Authentication required
- Terms of use
- Create a new project
 - *Projects must be named*
 - *Pre-populated templates*
- Layer panel on right-hand side
- Fire input conditions
 - *Tools on lower left*
- Basic simulation parameters
 - *Start date and time*
 - *Time zone*
 - *Simulation duration*
 - *Simulation resolution*
- Project controls
- Progress
 - *Shows when you press 'Run'*
 - *Any errors reported at this stage*
- Output of fire simulation
 - *Colours represent hourly progress*



SparkWeb

Results and visualisation

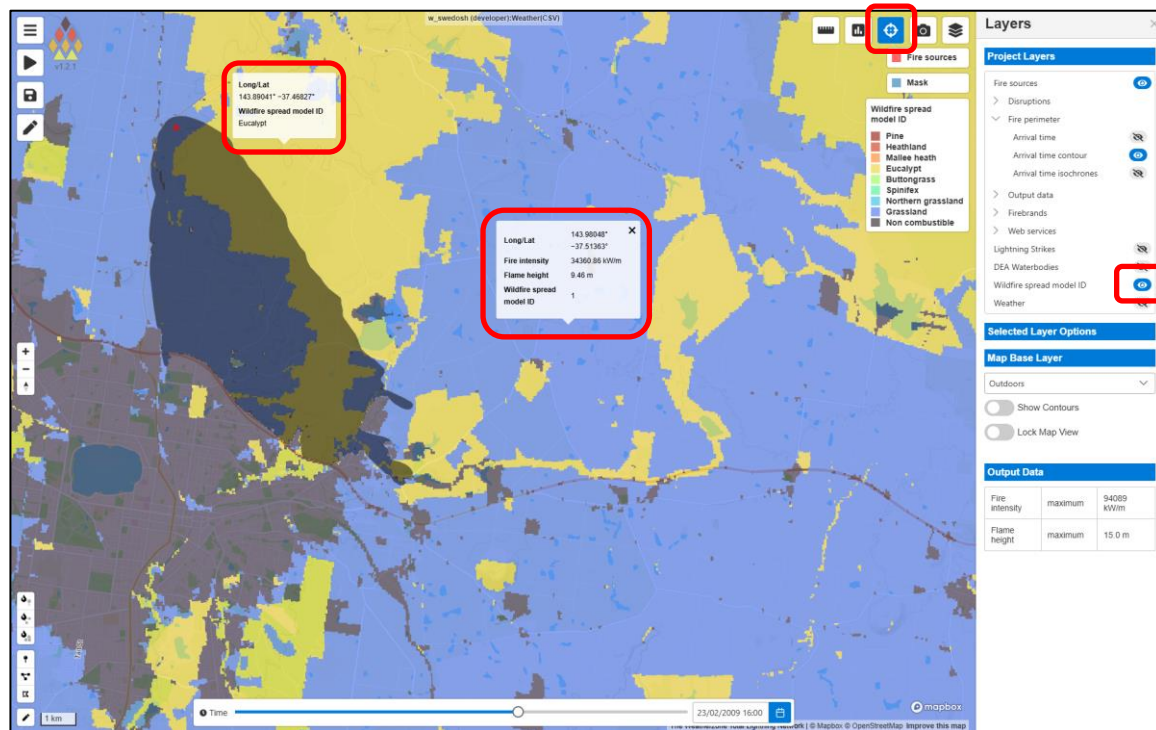
- Layers
 - List on right-hand side
 - Visibility controlled by view icons
- Shaded fire contour
 - Dynamic outline based on time slider



SparkWeb


Results and visualisation

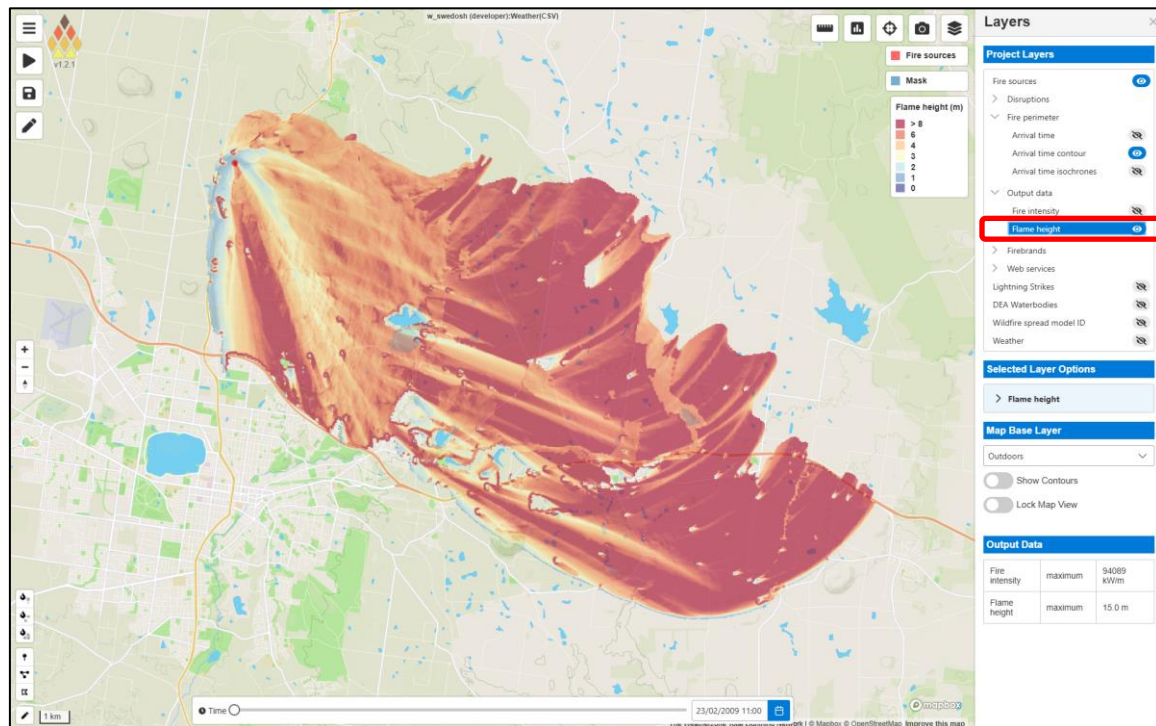
- Layers
 - List on right-hand side
 - Visibility controlled by view icons
- Shaded fire contour
 - Dynamic outline based on time slider
- Wildfire model layer
 - Cell evaluation using inspection tool
 - Current value of all visible layers under mouse
 - Left click for all layer values (shows fireline intensity etc.)



SparkWeb


Results and visualisation

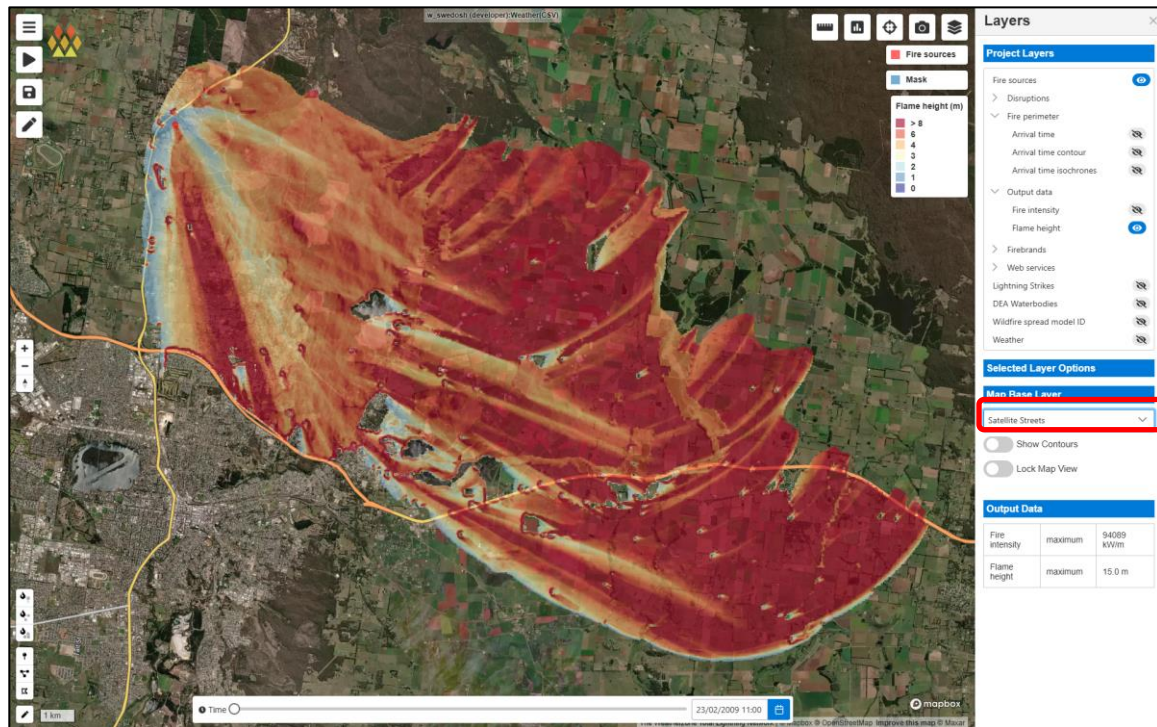
- Layers
 - List on right-hand side
 -  Visibility controlled by view icons
- Shaded fire contour
 - Dynamic outline based on time slider
- Wildfire model layer
 - Cell evaluation using inspection tool
 - Current value of all visible layers under mouse
- Flame height layer
 - Fireline intensity also available



SparkWeb

Results and visualisation

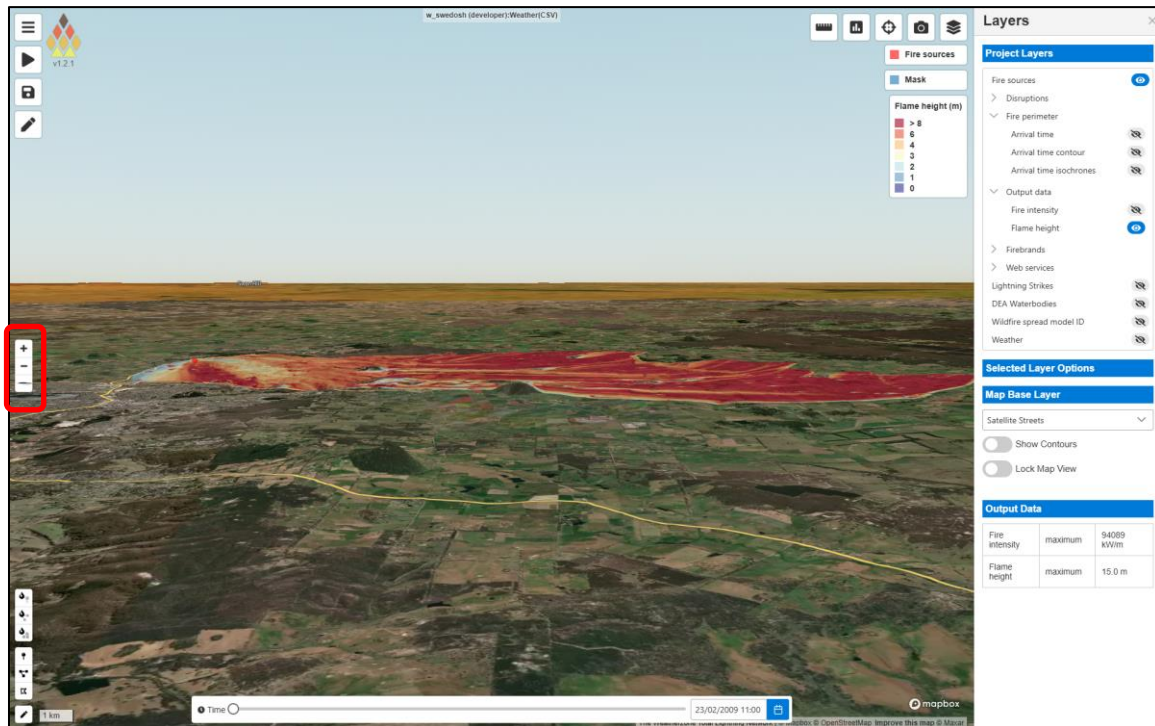
- Layers
 - *List on right-hand side*
 -  *Visibility controlled by view icons*
- Shaded fire contour
 - *Dynamic outline based on time slider*
- Wildfire model layer
 - *Cell evaluation using inspection tool*
 - *Current value of all layers under mouse*
- Flame height layer
- Base map
 - *Various base map options*



SparkWeb

Results and visualisation

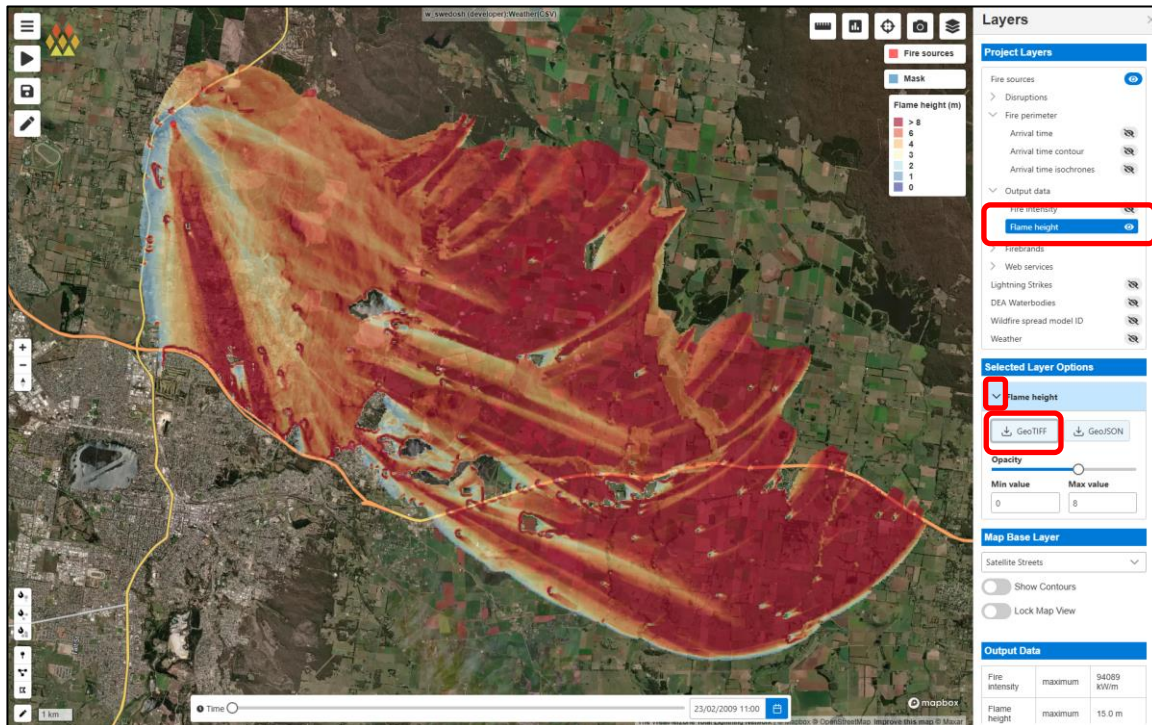
- Layers
 - List on right-hand side
 - Visibility controlled by view icons
- Shaded fire contour
 - Dynamic outline based on time slider
- Wildfire model layer
 - Cell evaluation using inspection tool
 - Current value of all layers under mouse
- Flame height layer
- Base map
 - Various base map options
- 3D view
 - Right mouse or ctrl+left mouse to rotate view
 - Mousewheel to zoom
 - View reset using compass button



SparkWeb

Results and visualisation

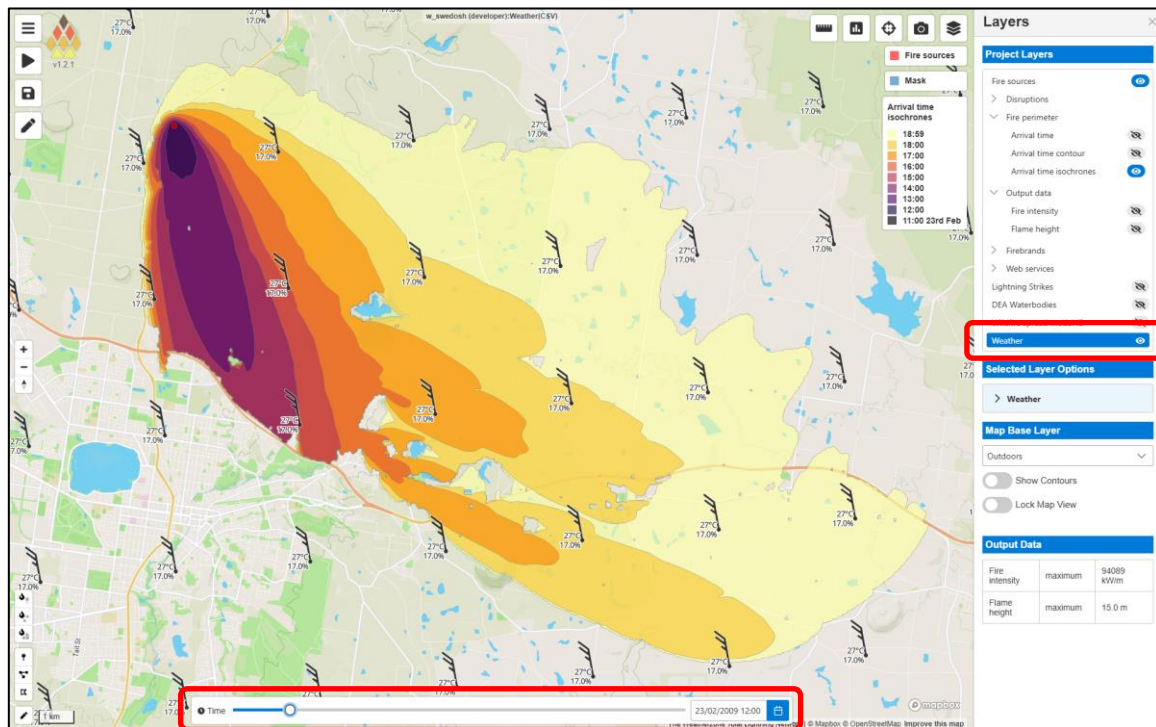
- Layers
 - List on right-hand side
 - Visibility controlled by view icons
- Shaded fire contour
 - Dynamic outline based on time slider
- Wildfire model layer
 - Cell evaluation using inspection tool
 - Current value of all layers under mouse
- Flame height layer
- Base map
 - Various base map options
- 3D view
 - Right mouse or ctrl+left mouse to rotate view
 - Mousewheel to zoom
 - View reset using compass button
- Layer options
 - Layer download buttons
 - Opacity slider
 - Colour map
 - Colour range
- Layer download
 - Defaults to 'Downloads' folder if no directory selected



SparkWeb

Results and visualisation

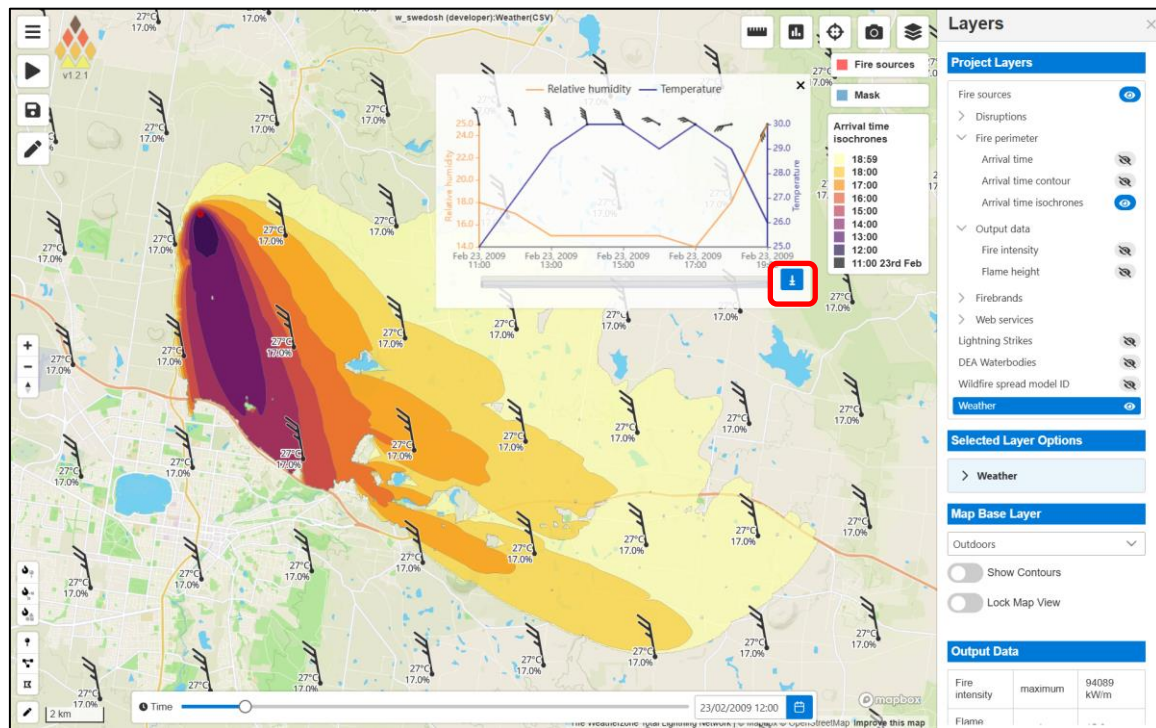
- Layers
 - List on right-hand side
 - Visibility controlled by view icons
- Shaded fire contour
 - Dynamic outline based on time slider
- Wildfire model layer
 - Cell evaluation using inspection tool
 - Current value of all layers under mouse
- Flame height layer
- Base map
 - Various base map options
- 3D view
 - Right mouse or ctrl+left mouse to rotate view
 - Mousewheel to zoom
 - View reset using compass button
- Layer options
 - Layer download buttons
 - Opacity slider
 - Colour map
 - Colour range
- Layer download
- Weather visualisation
 - Changes with time slider



SparkWeb

Results and visualisation

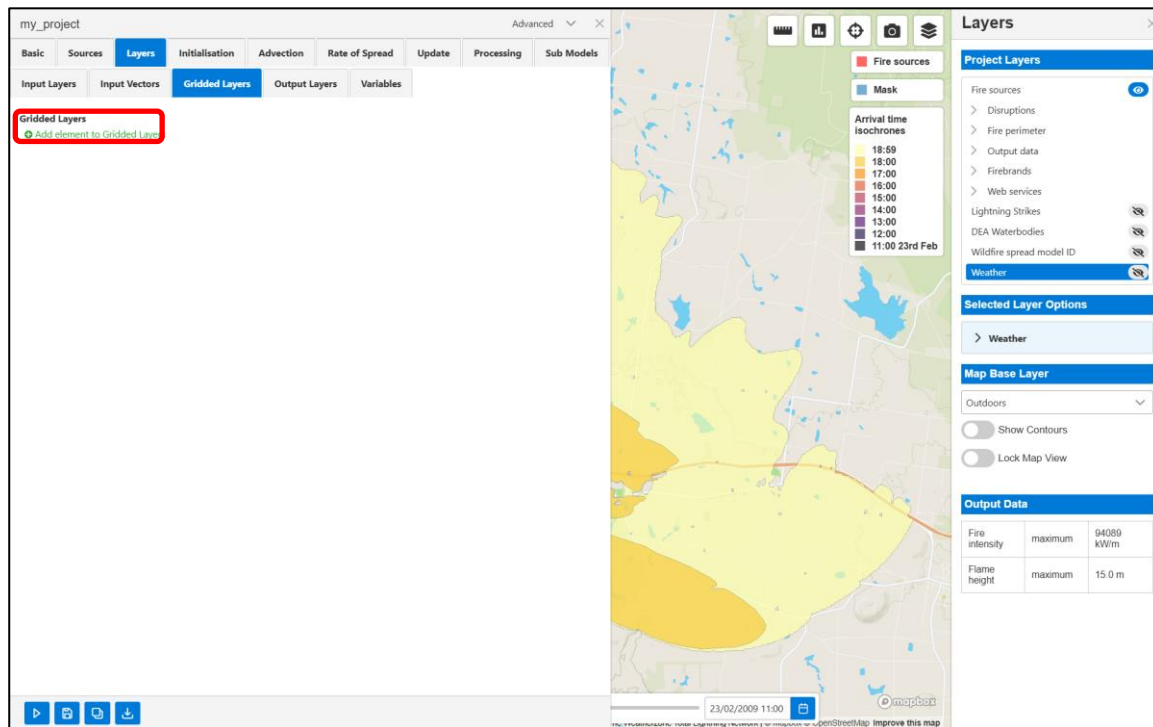
- Layers
 - List on right-hand side
 - Visibility controlled by view icons
- Shaded fire contour
 - Dynamic outline based on time slider
- Wildfire model layer
 - Cell evaluation using inspection tool
 - Current value of all layers under mouse
- Flame height layer
- Base map
 - Various base map options
- 3D view
 - Right mouse or ctrl+left mouse to rotate view
 - Mousewheel to zoom
 - View reset using compass button
- Layer options
 - Layer download buttons
 - Opacity slider
 - Colour map
 - Colour range
- Layer download
- Weather
 - Changes with time slider
 - Shows time series chart when icon is clicked
 - Can be downloaded as a csv



SparkWeb

Advanced usage

- Weather inputs
 - *Spark requires whatever weather variables your rate of spread models use as inputs*
 - *Generally wind speed and direction, relative humidity and temperature*
 - *Could also include drought factor, dew temperature, curing*
 - *Can be uploaded as a set of gridded netcdf files*
 - *We have guides to use BARRA-R2, ERA5, ops_aps2 and ops_APS3 data sets for historical reconstructions*



SparkWeb

Advanced usage

- Weather inputs
 - Spark requires whatever weather variables your rate of spread models use as inputs
 - Generally wind speed and direction, relative humidity and temperature
 - Could also include drought factor, dew temperature, curing
 - Can be uploaded as a set of gridded netcdf files
 - Or a suitable weather csv file can be dragged and dropped into the 'Simulation series CSV' input
 - Example csv format:

date	relative_humidity	temperature	wind_direction	wind_magnitude	
2009-02-23T11:00:00+11:00	18	25	350	15	
2009-02-23T12:00:00+11:00	17	27	350	25	
2009-02-23T13:00:00+11:00	15	29	350	39	
2009-02-23T14:00:00+11:00	15	30	350	39	
2009-02-23T15:00:00+11:00	15	30	340	39	
2009-02-23T16:00:00+11:00	15	29	300	30	
2009-02-23T17:00:00+11:00	14	30	300	33	
2009-02-23T18:00:00+11:00	18	29	260	33	
2009-02-23T19:00:00+11:00	25	26	210	30	

The screenshot shows the SparkWeb interface for a project named 'my_project'. The 'Basic' tab is active, displaying simulation parameters. The 'Simulation weather data' field is highlighted with a red box and contains the file 'met.csv'. The interface also shows a map with fire sources and arrival time isochrones, and a 'Layers' panel on the right.

my_project Advanced

Basic Sources Layers Initialisation Advection Rate of Spread Update Processing Sub Models

Start time
23/02/2009 11:00

Set start time as current time

Start time timezone
+11:00

Simulation duration (hours)
8

Options
Add element to Options

Simulation resolution (m)
30

Notes

Simulation ensembles (max 12)
1

Simulation projection
EPSG:3112

Random Seed

Simulation weather data
met.csv

Simulation output projection
EPSG:3857

Template Version

Layers

Project Layers

Fire sources

Mask

Arrival time isochrones

18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00 23rd Feb

Selected Layer Options

Weather

Map Base Layer

Outdoors

Show Contours

Lock Map View

Output Data





Fire intensity maximum 94089 kW/m

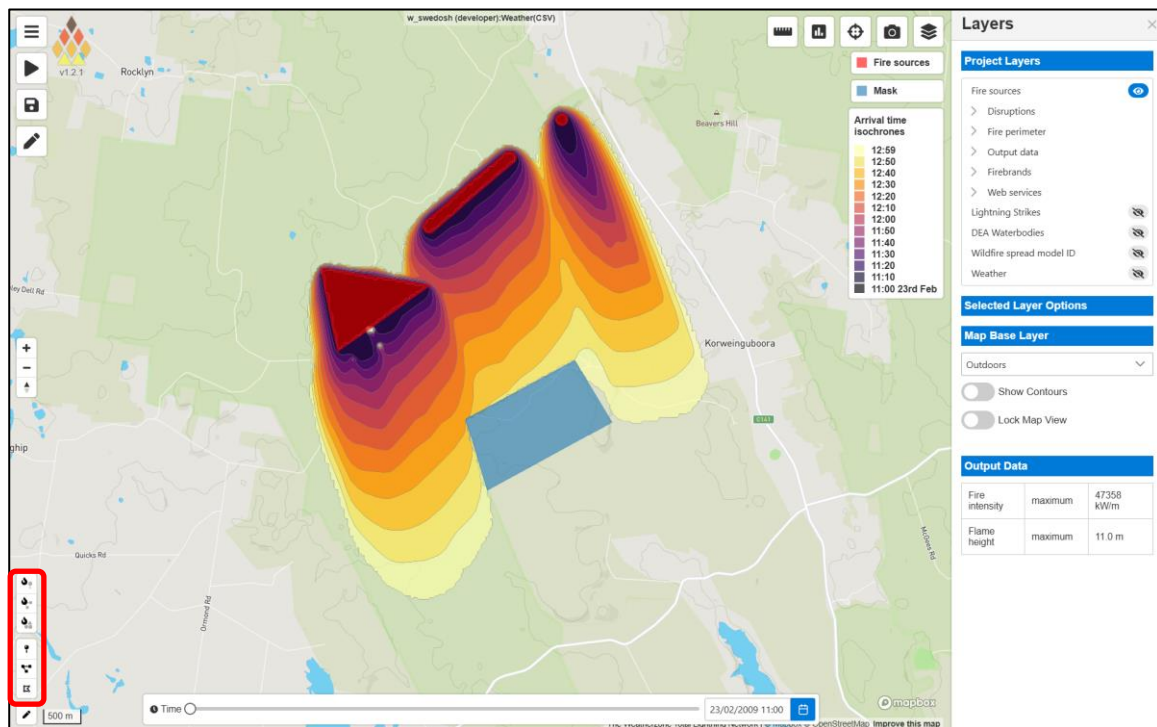
Flame height maximum 15.0 m

SparkWeb

Advanced usage

- Input tools

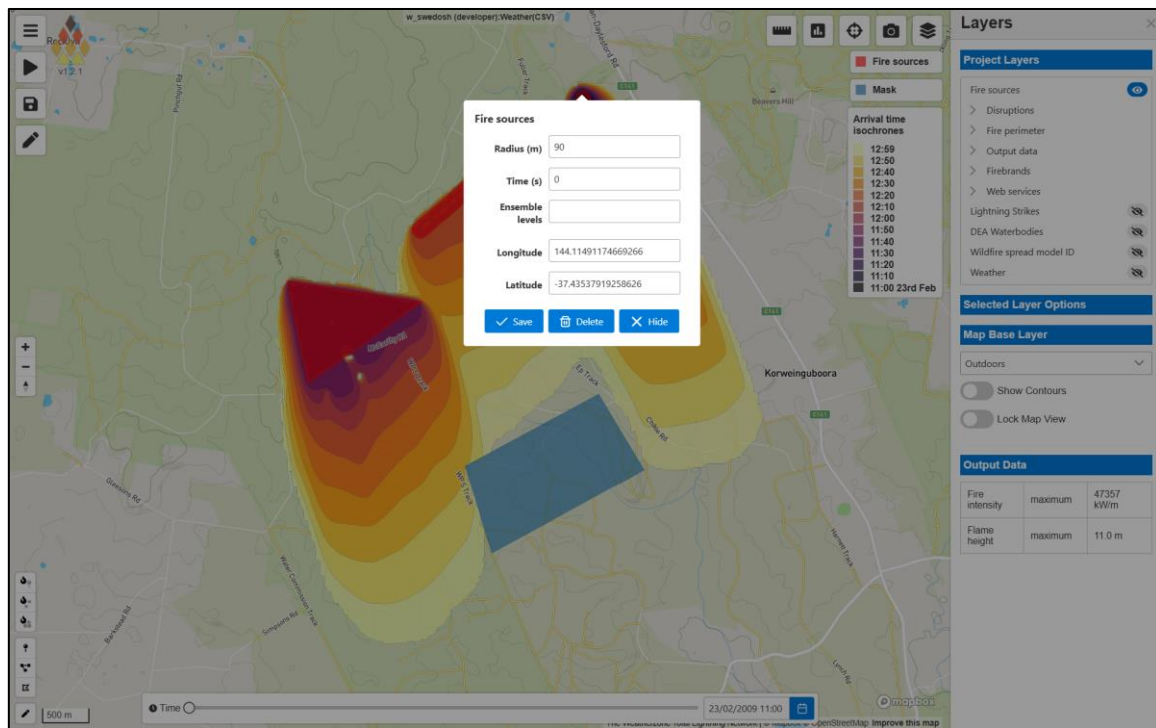
-  Point fire creation
-  Line fire creation
-  Polygon fire creation
-  Mask creation (un-burnable by default, but can be used to modify input values)



SparkWeb

Advanced usage

- Input tools
 - *Point fire creation*
 - *Line fire creation*
 - *Polygon fire creation*
 - *Mask (un-burnable) creation*
- Multiple ignitions
 - *Different start times*
 - *Left-click to configure*
 - *Set geometry properties*
 - *Set ignition time*
 - *Set position*



SparkWeb

Advanced usage

- Advanced options
 - *All layers and options available*

The screenshot displays the SparkWeb interface for a project named 'my_project'. The interface is divided into several sections:

- Navigation:** A top menu bar includes 'Basic', 'Sources', 'Layers', 'Initialisation', 'Advection', 'Rate of Spread', 'Update', 'Processing', and 'Sub Models'. The 'Sources' tab is highlighted with a red box.
- Simulation Settings (Left Panel):**
 - Start time:** 23/02/2009 11:00
 - Set start time as current time:** Toggle off
 - Start time timezone:** +11:00
 - Simulation duration (hours):** 2
 - Options:** 'Add element to Options' button
 - Simulation resolution (m):** 30
 - Notes:** Empty text area
 - Simulation ensembles (max 12):** 1
 - Simulation projection:** EPSG:3112
 - Random Seed:** Empty text area
 - Simulation weather data:** meL.csv
 - Simulation output projection:** EPSG:3857
 - Template Version:** Empty text area
 - Enable Plumes:** Toggle off
 - Enable Firebrands:** Toggle off
- Map (Center):** A map showing a fire spread simulation. A color-coded isochrone map is overlaid on a satellite-style map. A legend titled 'Arrival time isochrones' shows a color scale from 11:00 (dark purple) to 12:58 (yellow). The map shows a fire source at the top left, spreading towards the bottom right.
- Layers (Right Panel):**
 - Project Layers:** Includes 'Fire sources', 'Mask', 'Disruptions', 'Fire perimeter', 'Output data', 'Firebrands', 'Web services', 'Lightning Strikes', 'DEA Waterbodies', 'Wildfire spread model ID', and 'Weather'.
 - Selected Layer Options:** Includes 'Map Base Layer' (set to 'Outdoors') and 'Show Contours' (toggle off).
 - Output Data:** A table showing maximum values for 'Fire intensity' (47357 kW/m) and 'Flame height' (11.0 m).

SparkWeb

Advanced usage

- Advanced options
 - *All layers and options available*
- Layers
 - *Input layers – Land classification, elevation, fuel age, disruptions...*

The screenshot shows the SparkWeb interface for a fire simulation project named "my_project". The interface is divided into several sections:

- Top Navigation:** Includes tabs for "Basic", "Sources", "Layers" (selected), "Initialisation", "Advection", "Rate of Spread", "Update", "Processing", and "Sub Models".
- Input Layers Panel:** A table with columns "Name", "Source", "Projection", and "Type".

Name	Source	Projection	Type
elevation	/geowebfs/data/AUS_DEM_16_EPSG3112	EPSG:3112	Float
classification	/geowebfs/data/AUS_ALUM_16_EPSG311	EPSG:3112	Integer
- Map:** Displays a fire simulation map with a fire perimeter and arrival time isochrones. A legend for "Arrival time isochrones" shows a color scale from 12:59 (yellow) to 11:00 (dark grey). The map includes labels for "Beavers Hill", "Korweinguboorra", and "Chowee Rd".
- Layers Panel:** Contains "Project Layers" (Fire sources, Disruptions, Fire perimeter, Output data, Firebrands, Web services, Lightning Strikes, DEA Waterbodies, Wildfire spread model ID, Weather) and "Selected Layer Options" (Map Base Layer: Outdoors, Show Contours, Lock Map View).
- Output Data Panel:** A table showing simulation results.

Fire intensity	maximum	47357 kW/m
Flame height	maximum	11.0 m
- Bottom Bar:** Includes a date and time display "23/02/2009 11:00" and a "mapbox" logo.

SparkWeb

Advanced usage

- Advanced options
 - *All layers and options available*
- Layers
 - *Input layers – Land classification, elevation, fuel age, disruptions...*
 - *Vector layers – Can be used to overwrite input layers or set unburnable areas by drawing lines / polygons*

my_project

Advanced

Basic Sources **Layers** Initialisation Advection Rate of Spread Update Processing Sub Models

Input Layers **Input Vectors** Gridded Layers Output Layers Variables

Input Vectors

Name	Source	Projection	Mapping
mask		EPSG:4326	Distance

Add element to Input Vectors

Arrival time isochrones

- 12:59
- 12:50
- 12:40
- 12:30
- 12:20
- 12:10
- 12:00
- 11:50
- 11:40
- 11:30
- 11:20
- 11:10
- 11:00 23rd Feb

Layers

Project Layers

- Fire sources
- Disruptions
- Fire perimeter
- Output data
- Firebrands
- Web services
- Lightning Strikes
- DEA Waterbodies
- Wildfire spread model ID
- Weather

Selected Layer Options

Map Base Layer

Outdoors

Show Contours

Lock Map View

Output Data

Fire intensity	maximum	47357 kW/m
Flame height	maximum	11.0 m

23/02/2009 11:00

mapbox

SparkWeb

Advanced usage

- Advanced options
 - *All layers and options available*
- Layers
 - *Input layers – Land classification, elevation, fuel age, disruptions...*
 - *Vector layers – Can be used to overwrite input layers or set unburnable areas by drawing lines / polygons*
 - *Gridded layers – Meteorological netcdf files*
 - *Output layers – Creates rasters which can be written to in initialisation, rate of spread or output models. Any with descriptions are visualised in Project Layers after simulation is run. Reductions shown in Output Data table at completion of simulation*

The screenshot displays the SparkWeb interface for a project named 'my_project'. The 'Layers' tab is active, showing the 'Output Layers' configuration table. A red box highlights the 'Reduction' column in this table. To the right, a map shows a fire simulation area with a color-coded 'Arrival time isochrones' legend. Below the map, the 'Output Data' table is visible, also highlighted with a red box.

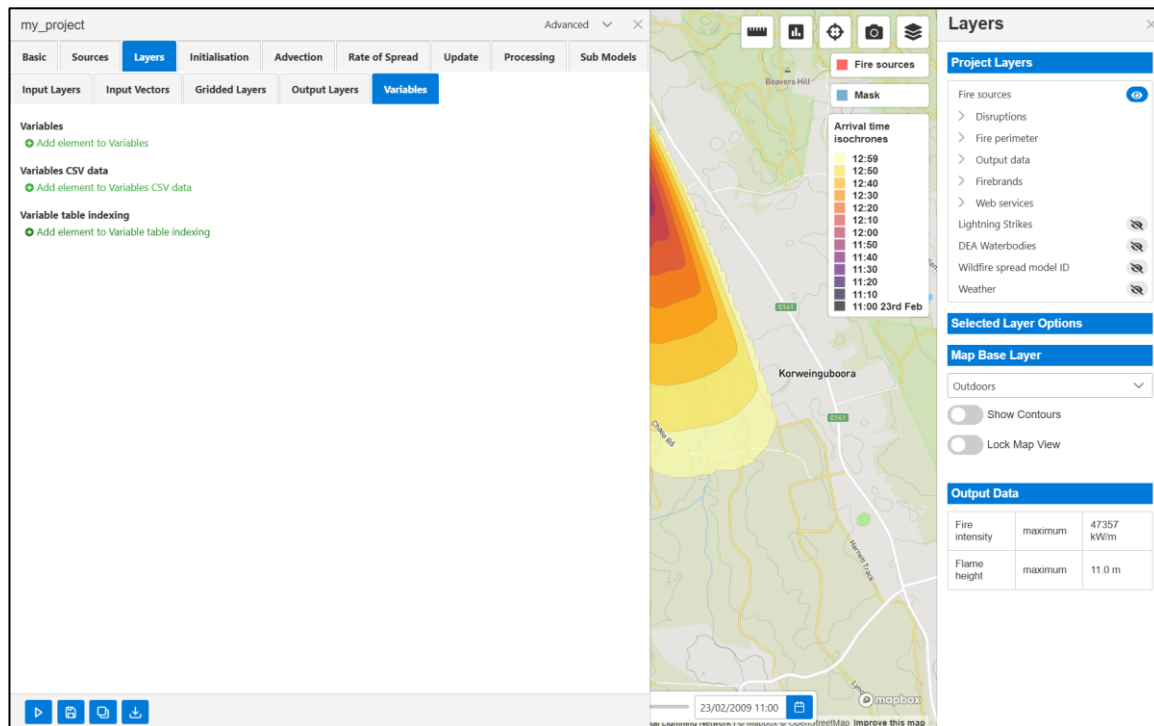
Name	Description	Units	Sampling	Reduction	Flat
model_id	Wildfire spread model ID		Nearest	None	
fire_history			Linear	None	
fuel_load			Linear	None	
intensity	Fire intensity	kW/m	Linear	Maximum	
flame_height	Flame height	m	Linear	Maximum	
firebrand_max_dist			Linear	None	
firebrand_creation	Firebrand creation		Linear	None	

Output Data		
Fire intensity	maximum	47357 kW/m
Flame height	maximum	11.0 m

SparkWeb

Advanced usage

- Advanced options
 - *All layers and options available*
- Layers
 - *Input layers – Land classification, elevation, fuel age, disruptions...*
 - *Vector layers – Can be used to overwrite input layers or set unburnable areas by drawing lines / polygons*
 - *Gridded layers – Meteorological netcdf files*
 - *Output layers – Creates rasters which can be written to in initialisation, rate of spread or output models. Any with descriptions are visualised in Project Layers after simulation is run. Reductions shown in Output Data table at completion of simulation*
 - *Variables – Can be used to set global variables for a simulation. CSV data can be uploaded and used as a look up table (e.g. for fuel attributes)*



SparkWeb

Advanced usage

- Models
 - Initialisation - Run once per cell. Can be used to set rate of spread model, fuel parameters etc. from input data*

The screenshot displays the SparkWeb interface for a fire simulation project named 'my_project'. The interface is divided into three main sections:

- Code Editor (Left):** Shows the 'Initialisation model' code. The code includes comments and logic for setting fuel types based on classification layers. Key parameters include a fire history of 18 years and a fuel load of 10 t/ha. The code uses conditional logic to assign fuel classes (e.g., Water, Forest, Grassland) based on the main and sub-class values of the input classification layer.
- Map (Center):** Displays a map of the area around Korweinguboora, showing a fire spread isochrone. The isochrone is color-coded by arrival time, ranging from 12:59 (yellow) to 11:00 23rd Feb (dark purple). A fire source is marked with a red square near Beavers Hill.
- Layers Panel (Right):** Contains a 'Layers' panel with 'Project Layers' and 'Selected Layer Options'. The 'Project Layers' list includes 'Fire sources', 'Disruptions', 'Fire perimeter', 'Output data', 'Firebrands', 'Web services', 'Lightning Strikes', 'DEA Waterbodies', 'Wildfire spread model ID', and 'Weather'. The 'Selected Layer Options' panel shows 'Map Base Layer' set to 'Outdoors' and options for 'Show Contours' and 'Lock Map View'. The 'Output Data' table shows a maximum fire intensity of 47357 kW/m and a maximum flame height of 11.0 m.

SparkWeb

Advanced usage

- Models

- Initialisation - Run once per cell*
- Advection - Used to modify wind field via `advect_x` and `advect_y` variables (EW and NS wind speed components)*
- Rate-of-spread, run to determine outward speed. 'Start' runs first for all models and is often used to calculate slope effects. Individual models are then run (for their respective grid cells), often to calculate head fire rate-of-spread. 'End' is then run which often applies the slope effect and applies a geometric template to spread the fire in 2D.*

The screenshot displays the SparkWeb interface for a project named 'my_project'. The 'Rate of Spread' tab is selected, showing a code editor with the following Fortran code:

```
7 // -----  
8 // CSIRO grasslands model  
9 // Model parameters:  
10 // 1. Temperature (degrees C), 'temp'  
11 // 2. Relative humidity (%), 'rel_hum'  
12 // 3. Wind speed (km/h), 'wind_speed'  
13 // 4. Curing value (%), 'curing'  
14 // -----  
15  
16 // -----  
17 // Specific to test  
18 const REAL curing = 00.0;  
19 // -----  
20  
21 // Calculate curing coefficient from Cruz et al. (2015)  
22 REAL curing_coeff = 0.0;  
23 if (curing >= 20.0) {  
24   curing_coeff = 1.036/(1.0+103.089*exp(-0.0996*(curing-20.0)));  
25 }  
26  
27 // Fuel moisture content approximated using McArthur (1966)  
28 REAL grasslands_moisture = 9.58-(0.205*temp)+(0.138*rel_hum);  
29  
30 // Calculate moisture coefficient from Cheney et al. (1998)  
31 REAL moisture_coeff;  
32 if (grasslands_moisture <= 12.0) {  
33   moisture_coeff = exp(-0.108*grasslands_moisture);  
34 } else if ( wind_speed <= 10 ) {  
35   moisture_coeff = 0.684-0.0342*grasslands_moisture;  
36 } else {  
37   moisture_coeff = 0.547-0.0228*grasslands_moisture;  
38 }  
39  
40 // Calculate head fire speed (km/hr)  
41 if (wind_speed >= 5.0) {  
42  
43   // Fast  
44   if (subclass == 1) {  
45  
46     // Natural: cb = 1.4, cw = 0.838  
47     speed = 1.440.838*pow((wind_speed-5.0), 0.844);  
48  
49   } else if (subclass == 2) {  
50  
51     // Cut or grazed: cb = 1.1, cw = 0.715
```


SparkWeb

Advanced usage

- Models

- Initialisation - Run once per cell*
- Advection - Used to modify wind field*
- Rate-of-spread, run to determine outward speed.*
- 'Start' runs first for all models and is often used to calculate slope effects. Individual models are then run (for their respective grid cells), often to calculate head fire rate-of-spread. 'End' is then run for all models which often applies the slope effect and applies a geometric template to spread the fire in 2D.*
- Update, runs within burnt regions. 'Start' runs first for all models. Individual models are then run (for their respective grid cells), often to calculate flame height and fireline intensity. 'End' is then run for all models which often calculates effects of disruptions.*

The screenshot displays the SparkWeb interface for a project named 'my_project'. The interface is divided into several sections:

- Code Editor:** Shows a 'Common start' script with the following code:

```
1 // Calculate intensity and flame height
2 intensity = max(intensity, 1000*speed*fuel_load*0.1);
3 flame_height = max(flame_height, 0.8775*pow(intensity, 0.46));
4
5 // Calculate firebrand maximum distance
6 firebrand_max_dist = 0.0;
7 if (class == 5 && time - arrival < 300.0) {
8   REAL firebrand_prob = 0.00001;
9   firebrand_prob = 1.0-pow((REAL)(1.0-firebrand_prob), time_step);
10  if (random < firebrand_prob) {
11
12    // Calculate maximum distance
13    firebrand_max_dist = max(speed*.0*(4.17-0.833*fuel_load)-3.6, 0.0)*1000.0;
14    if (firebrand_max_dist == 0) firebrand_max_dist = noData_REAL;
15
16    // Save areas of firebrand creation
17    firebrand_creation = max(firebrand_creation, firebrand_max_dist);
18  }
19 }
```
- Map:** A map showing a geographical area with a fire source marked by a red dot. A legend titled 'Arrival time isochrones' shows a color scale from 11:00 to 12:59. The map includes labels for 'orweinguboorra' and 'Lynx'.
- Layers Panel:** Titled 'Layers', it shows 'Project Layers' including 'Fire sources', 'Disruptions', 'Fire perimeter', 'Output data', 'Firebrands', 'Web services', 'Lightning Strikes', 'DEA Waterbodies', 'Wildfire spread model ID', and 'Weather'. Below this, 'Selected Layer Options' shows 'Map Base Layer' set to 'Outdoors' and options for 'Show Contours' and 'Lock Map View'. An 'Output Data' table is also present.
- Output Data Table:**

Fire intensity	maximum	47357 kW/m
Flame height	maximum	11.0 m

SparkWeb

Advanced usage

- Layer creation
 - Any number can be created
 - Name available in model scripts for reading/writing
 - Must have description to be visualised
 - Example 'test' layer created called 'Test'

The screenshot shows the SparkWeb interface for a project named 'my_project'. The 'Output Layers' tab is active, displaying a table of output layers. A new layer named 'test' with the description 'test' is highlighted in red. Below the table is a button labeled 'Add element to Output Layers'. The interface also includes a map showing a fire simulation, a 'Layers' panel on the right, and a 'Project Layers' list.

Name	Description	Units	Sampling	Reduction	Flat
model_id	Wildfire spread model ID		Nearest	None	<input type="checkbox"/>
fire_history			Linear	None	<input type="checkbox"/>
fuel_load			Linear	None	<input type="checkbox"/>
intensity	Fire intensity	kW/m	Linear	Maximum	<input type="checkbox"/>
flame_height	Flame height	m	Linear	Maximum	<input type="checkbox"/>
firebrand_max_dist			Linear	None	<input type="checkbox"/>
firebrand_creation	Firebrand creation		Linear	None	<input type="checkbox"/>
test	test		Nearest	None	<input type="checkbox"/>

Map: Arrival time isochrones (12:59 to 11:00 23rd Feb). Locations: Beavers Hill, Korweinguboora, Kulum Paddock.

Layers Panel: Project Layers (Fire sources, Disruptions, Fire perimeter, Output data, Firebrands, Web services, Lightning Strikes, DEA Waterbodies, Wildfire spread model ID, Weather). Selected Layer Options: Map Base Layer (Outdoors). Output Data: Fire intensity (maximum 47357 kW/m), Flame height (maximum 11.0 m).

SparkWeb

Advanced usage

- Layer creation
 - Any number can be created
 - Name available in model scripts for reading/writing
 - Must have description to be visualised
 - Example 'test' layer created called 'Test'
- Scripting
 - Layer is written in update model
 - Anywhere where flame height > 3 test is 1
 - Elsewhere test is null

The screenshot displays the SparkWeb interface for a project named 'my_project'. The interface is divided into several sections:

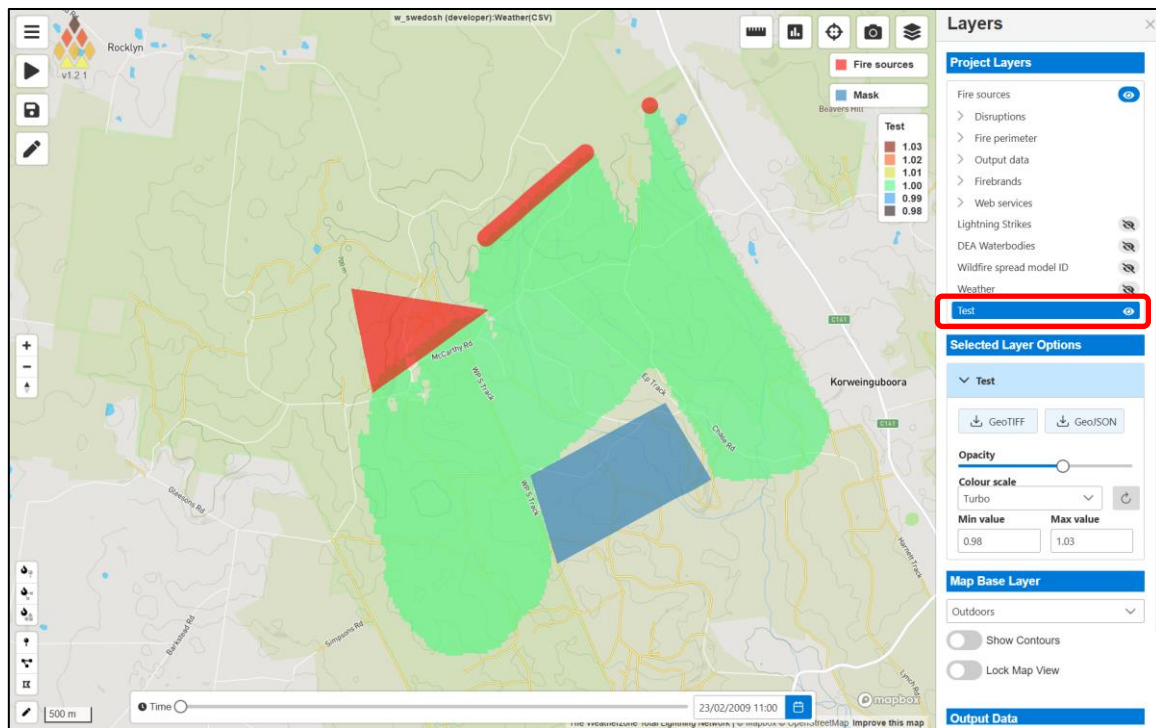
- Model Script:** A code editor showing a script with various parameters and a 'test' layer creation logic. The logic is highlighted with a red box:

```
21 if (flame_height > 3){
22   test = 1;
23 }
```
- Map:** A map showing the spatial distribution of fire sources and isochrones. The isochrones are color-coded by arrival time, ranging from 12:59 (yellow) to 11:00 23rd Feb (dark grey).
- Layers Panel:** A panel on the right side of the interface showing the 'Project Layers' and 'Selected Layer Options'. The 'Project Layers' section lists various layers, including 'Fire sources', 'Disruptions', 'Fire perimeter', 'Output data', 'Firebrands', 'Web services', 'Lightning Strikes', 'DEA Waterbodies', 'Wildfire spread model ID', and 'Weather'. The 'Selected Layer Options' section shows the 'Map Base Layer' set to 'Outdoors' and options for 'Show Contours' and 'Lock Map View'.
- Output Data:** A table at the bottom right showing the maximum values for 'Fire intensity' (47357 kW/m) and 'Flame height' (11.0 m).

SparkWeb

Advanced usage

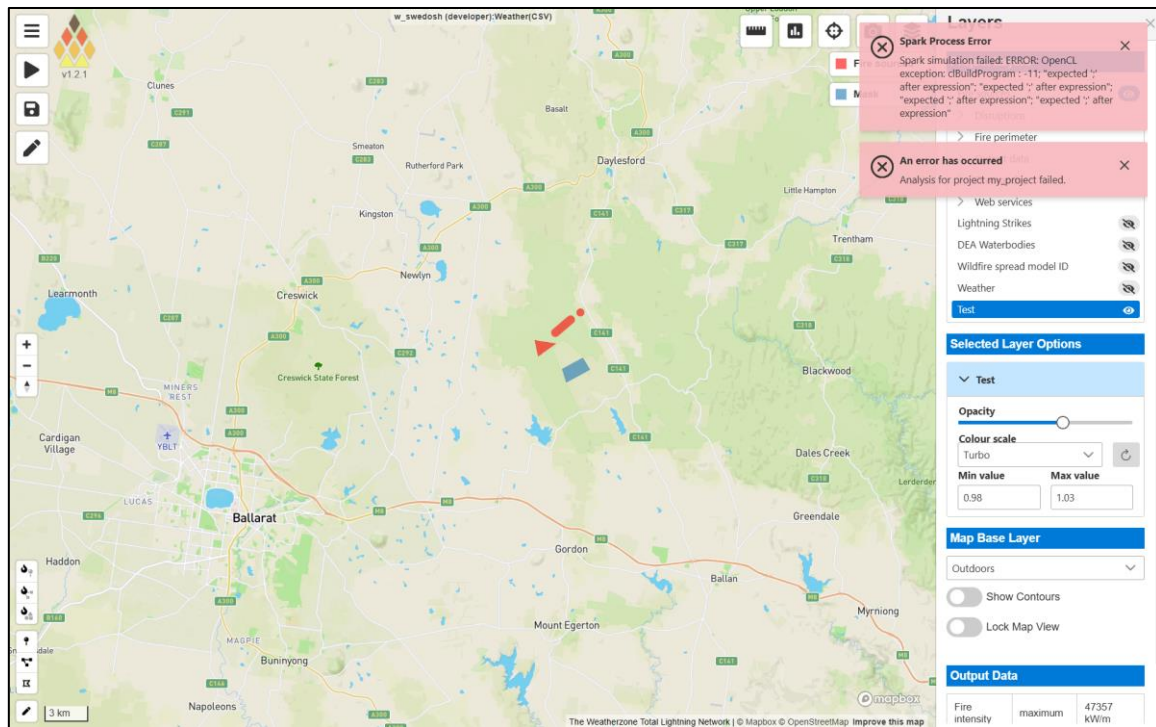
- Layer creation
 - Any number can be created
 - Name available in model scripts for reading/writing
 - Must have description to be visualised
 - Example 'test' layer created called 'Test'
- Scripting
 - Layer is written in update model
 - Anywhere where flame height > 3 test is 1
 - Elsewhere test is null
- Visualisation
 - Data from 'Test' shown in green after simulation is run again



SparkWeb

Advanced usage

- Layer creation
 - Any number can be created
 - Name available in model scripts for reading/writing
 - Must have description to be visualised
 - Example 'test' layer created called 'Test'
- Scripting
 - Layer is written in update model
 - Anywhere where flame height > 1 test is 1
 - Elsewhere test is null
- Visualisation
 - Data from 'Test' shown in green after simulation is run again
- Errors
 - Errors appear in a red box
 - Script errors trigger 'Spark simulation failed'
 - Reported as a 'clBuildProgram: -11' exception
 - We will make this more intelligible!
 - The full error log is available in the API response



SparkWeb

Advanced usage

- Rate-of-spread scripts
 - *Script for each fuel classification type*
 - *Each type is an integer identifier 'class'*
 - *Zero is reserved for un-burnable*
 - *Classes can be named*

my_project Advanced

Basic Sources Layers Initialisation Advection **Rate of Spread** Update Processing Sub Models

Start End 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

Model Name

Radial spread

```
1 speed = 0.5;
```

Layers

Project Layers

- Fire sources
- > Fire perimeter
- > Output data
- > Firebrands
- > Web services
- Lightning Strikes
- DEA Waterbodies
- Wildfire spread model ID
- Weather

Selected Layer Options

Map Base Layer

Outdoors

Show Contours

Lock Map View

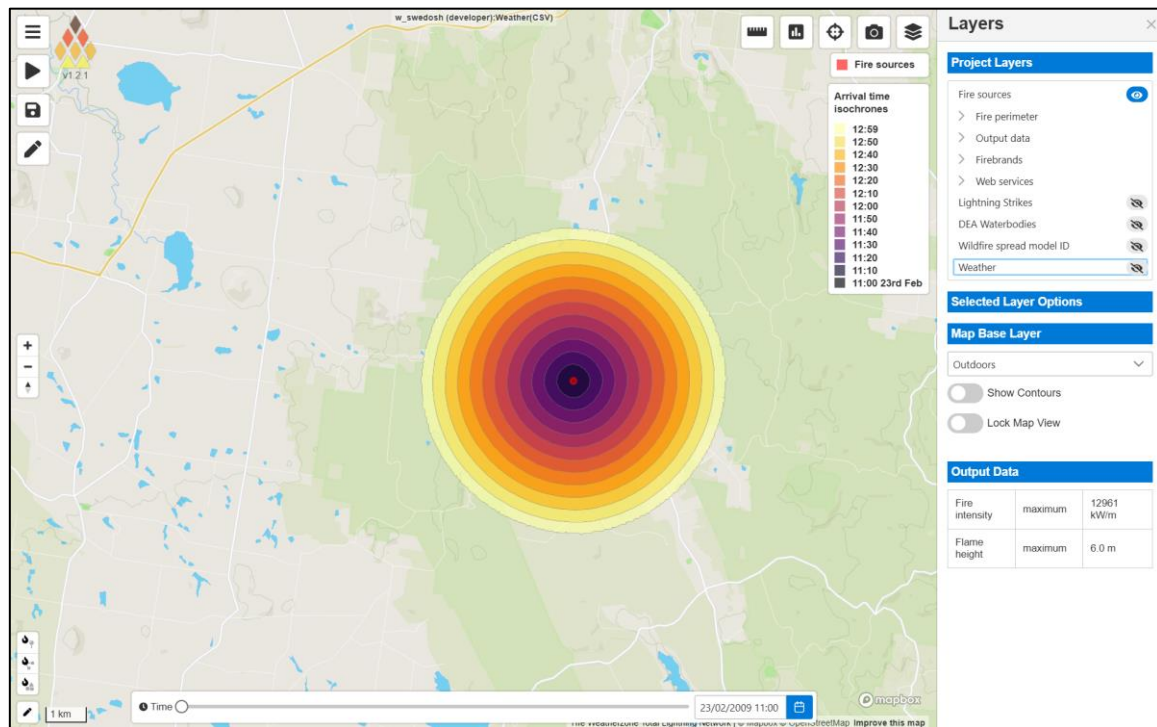
Output Data

Fire intensity	maximum	145238 kW/m
Flame height	maximum	18.4 m

SparkWeb

Advanced usage

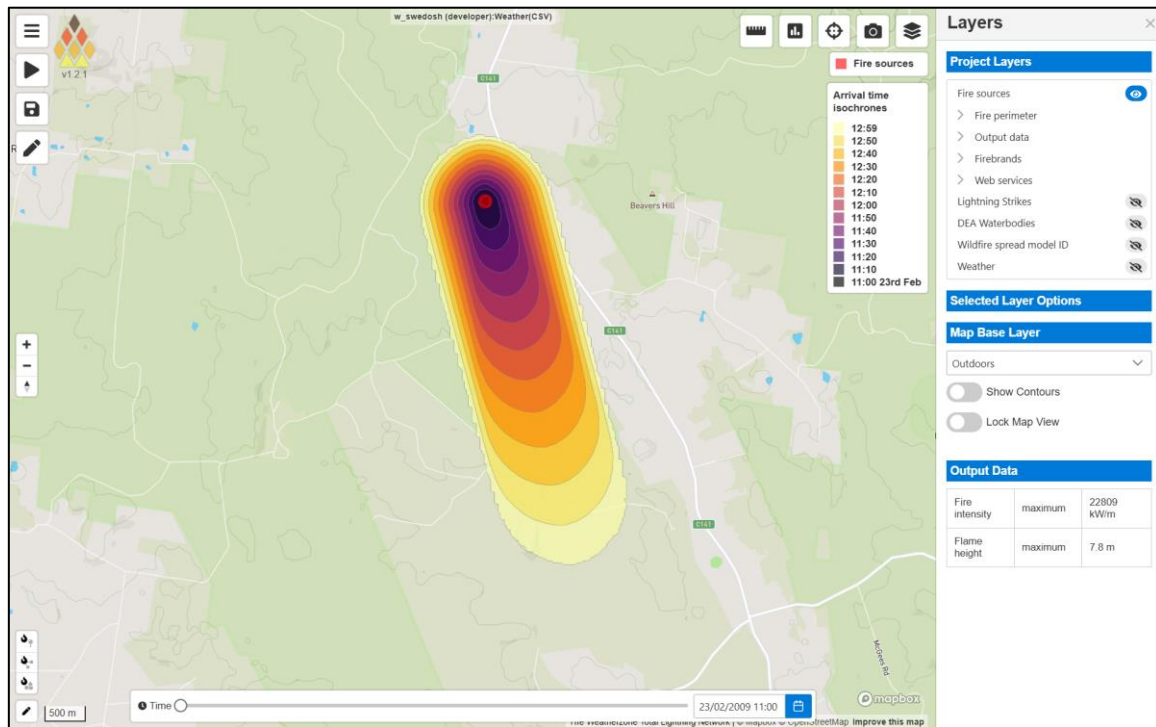
- Rate-of-spread scripts
 - *Script for each fuel classification type*
 - *Each type is an integer identifier 'class'*
 - *Zero is reserved for un-burnable*
 - *Classes can be named*
- Example 1
 - *Script "speed = 0.5;"*
 - *Sets outward speed to 0.5 m/s*
 - *Resulting fire is circular*



SparkWeb

Advanced usage

- Rate-of-spread scripts
 - *Script for each fuel classification type*
 - *Each type is an integer identifier 'class'*
 - *Zero is reserved for un-burnable*
 - *Classes can be named*
- Example 1
 - *Script "speed = 0.5;"*
 - *Sets outward speed to 0.5 m/s*
 - *Resulting fire is circular*
- Example 2
 - *Script "speed = 0.1+0.02*wind;"*
 - *Adds component in wind direction*
 - *Resulting fire grows outwards and moves with wind*



SparkWeb

Advanced usage – Sub Models

- Firebrand model
 - *Eucalypt forest empirical firebrand model*
 - *Requires script (update model) to determine creation*

The screenshot displays the SparkWeb interface for a project named 'my_project'. The interface is divided into several sections:

- Navigation Bar:** Includes tabs for 'Basic', 'Sources', 'Layers', 'Initialisation', 'Advection', 'Rate of Spread', 'Update' (highlighted), 'Processing', and 'Sub Models'. A timeline below these tabs shows steps from 1 to 20.
- Code Editor:** Contains a script for calculating firebrand parameters. The script includes comments and calculations for intensity, flame height, firebrand maximum distance, and firebrand creation.
- Map:** A satellite map showing a landscape with a fire source and isochrones. A legend titled 'Arrival time Isochrones' lists times from 12:59 to 11:00 23rd Feb.
- Layers Panel:** Shows 'Project Layers' including 'Fire sources', 'Fire perimeter', 'Output data', 'Firebrands', 'Web services', 'Lightning Strikes', 'DEA Waterbodies', 'Wildfire spread model ID', and 'Weather'. Below this is the 'Selected Layer Options' section, which includes 'Map Base Layer' (set to 'Outdoors') and 'Output Data' (showing 'Fire intensity' maximum at 22809 kW/m and 'Flame height' maximum at 7.8 m).

SparkWeb

Advanced usage – Sub Models

- Firebrand model
 - *Eucalypt forest empirical firebrand model*
 - *Requires script to determine creation*
 - *Models for all firebrand stages*
 - *Creation script, sets new firebrand positions*
 - *Initialisation script, creates firebrands*
 - *Advection model, controls air flow*
 - *Update model, controls firebrand changes*
 - *Transport model, controls interaction with air flow*
 - *Basic spot fire creation only required one model*

The screenshot displays the SparkWeb interface for a project named 'my_project'. The 'Sub Models' tab is active, showing a code editor for the 'Creation model' with the following code:

```
1 REAL advect_mag = hypot(advect_x, advect_y);
2 if (firebrand_max_dist > 0.0) {
3   create = true;
4   x += firebrand_max_dist*advect_x/advect_mag;
5   y += firebrand_max_dist*advect_y/advect_mag;
6   z = 0.0;
7   t = 1.0;
8 }
9
```

The interface also features a map showing 'Arrival time isochrones' with a color scale from 12:59 (yellow) to 11:10 (dark purple). The 'Layers' panel on the right includes 'Project Layers' (Fire sources, Fire perimeter, Output data, Firebrands, Web services), 'Selected Layer Options' (Map Base Layer, Outdoors, Show Contours, Lock Map View), and 'Output Data' (Fire intensity: maximum 22809 kW/m, Flame height: maximum 7.8 m).

SparkWeb

Advanced usage – Sub Models

- Firebrand model
 - *Eucalypt forest empirical firebrand model*
 - *Requires script to determine creation*
 - ***Models for all firebrand stages***
 - *Creation script, sets new firebrand positions*
 - *Initialisation script, creates firebrands*
 - *Advection model, controls air flow*
 - *Update model, controls firebrand changes*
 - *Transport model, controls interaction with air flow*
 - *Basic spot fire creation only required one model*
- Plume model
 - *More physical basis for the transport of firebrands in a plume*
 - *Requires most of the physics based models above*
 - *Currently requires 3D weather layers. Simple plume model in development path*

The screenshot displays the SparkWeb interface for configuring a project named "my_project". The "Sub Models" tab is selected, showing configuration options for "Plumes". A red box highlights the "Models for all firebrand stages" section, which includes the following configuration items:

- Weather topography
- Weather atmosphere
- Fire power layer name
- Fire power threshold (MW): 1
- Update time interval (s): 0
- Initial vertical speed (m/s): 0
- Maximum distance (m): 0
- Distance step (m): 0
- Constants: Add element to Constants
- Creation model: 1

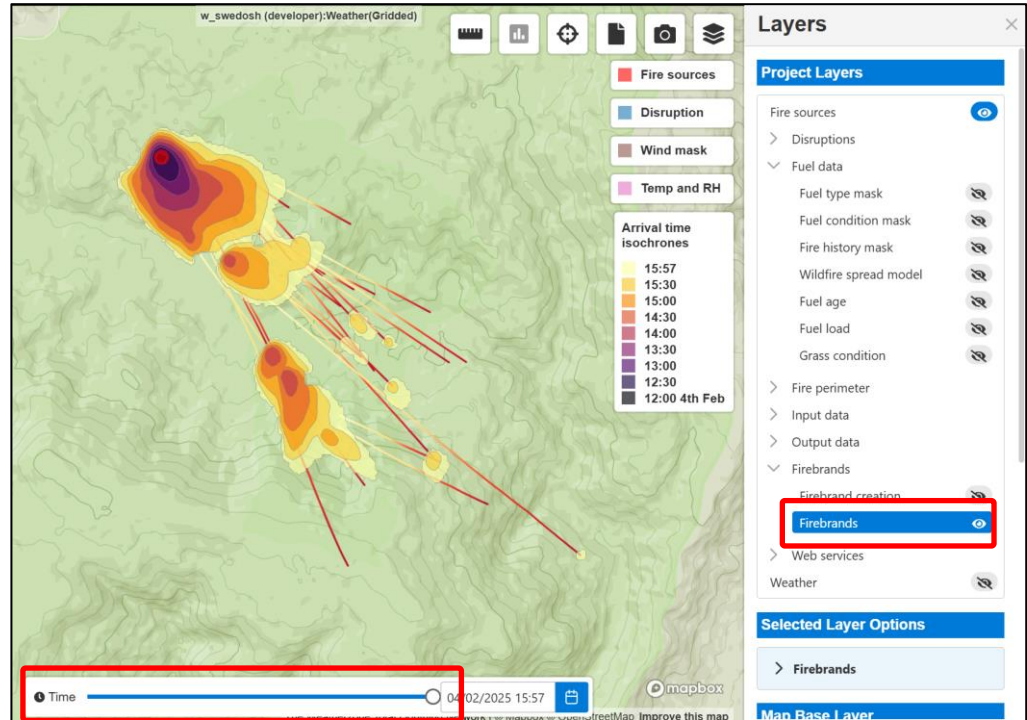
The interface also includes a map view on the right showing a legend for "Arrival time isochrones" and a "Layers" panel on the far right. The "Layers" panel shows "Project Layers" and "Selected Layer Options". The "Output Data" table is also visible:

Output Data	Value
Fire intensity	maximum 22809 kW/m
Flame height	maximum 7.8 m

SparkWeb

Advanced usage – Sub Models

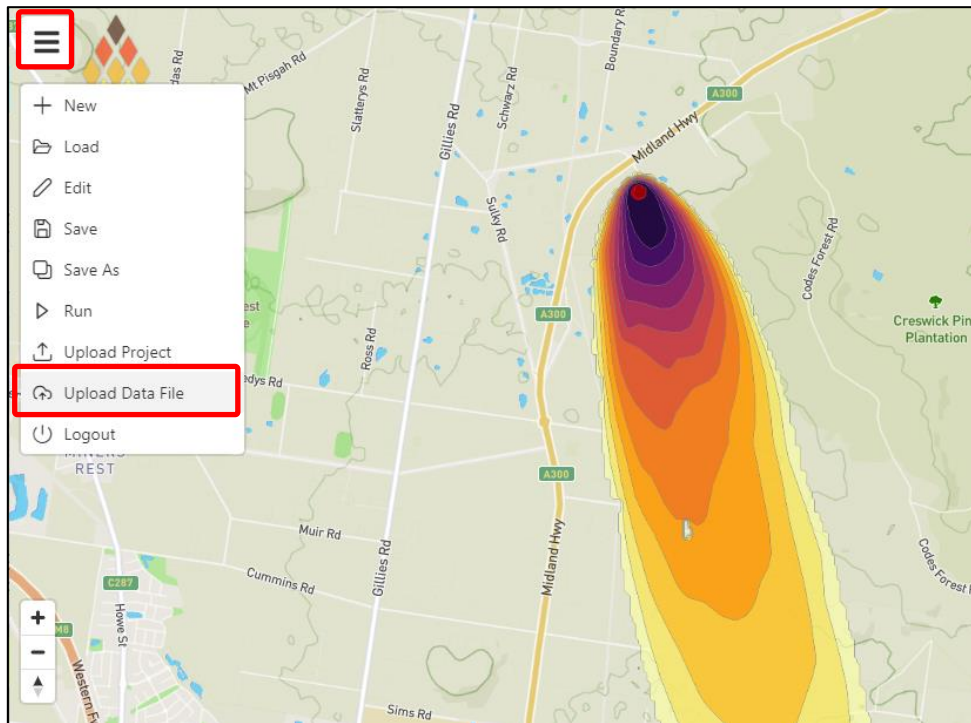
- Firebrand model
 - *Eucalypt forest empirical firebrand model*
 - *Requires script to determine creation*
 - *Models for all firebrand stages*
 - *Creation script, sets new firebrand positions*
 - *Initialisation script, creates firebrands*
 - *Advection model, controls air flow*
 - *Update model, controls firebrand changes*
 - *Transport model, controls interaction with air flow*
 - *Basic spot fire creation only required one model*
- Plume model
 - *More physical basis for the transport of firebrands in a plume*
 - *Requires most of the physics based models above*
 - *Currently requires 3D weather layers. Simple plume model in development path*
- Visualisation
 - *Firebrands which cause spot fires are visualised with yellow/red lines from generation to landing points*



SparkWeb

Advanced usage

- Uploading user data layers
 - *Note, the wildfire platform is currently open. Do not upload any sensitive data as other users will be able to use it. Please use specific filenames to ensure no duplicates (e.g. MY_USER_land_classification_EPSG_XXXX_v1.tiff)*



SparkWeb

Advanced usage

- Uploading user data layers
 - *Note, the wildfire platform is currently open. Do not upload any sensitive data as other users will be able to use it. Please use specific filenames to ensure no duplicates (e.g. MY_USER_land_classification_EPSG_XXXX_v1.tiff)*
 - *File is uploaded with the path: /geowebfs/uploads/FILENAME*
 - *Input the correct projection and data type as well as a name which can be referred to in the model scripts.*

Name	Source	Projection	Type
elevation	/geowebfs/data/AUS_DEM_16_EPSG3112	EPSG:3112	Float
classification	/geowebfs/data/AUS_ALUM_16_EPSG311	EPSG:3112	Integer
example_layer	/geowebfs/uploads/WS_example_tiff_v1.t	EPSG:4326	Float

➕ Add element to Input Layers

SparkWeb

Advanced usage

- Uploading user data layers
 - *Note, the wildfire platform is currently open. Do not upload any sensitive data as other users will be able to use it. Please use specific filenames to ensure no duplicates (e.g. MY_USER_land_classification_EPSG_XXXX_v1.tiff)*
 - *File is uploaded with the path: /geowebfs/uploads/FILENAME*
 - *Input the correct projection and data type as well as a name which can be referred to in the model scripts.*
- Visualising user data layers
 - *Create an output layer*

my_project

Basic Sources **Layers** Initialisation Advection Rate of Spread Update Processing Sub Models

Input Layers Input Vectors Gridded Layers **Output Layers** Variables

Output Layers

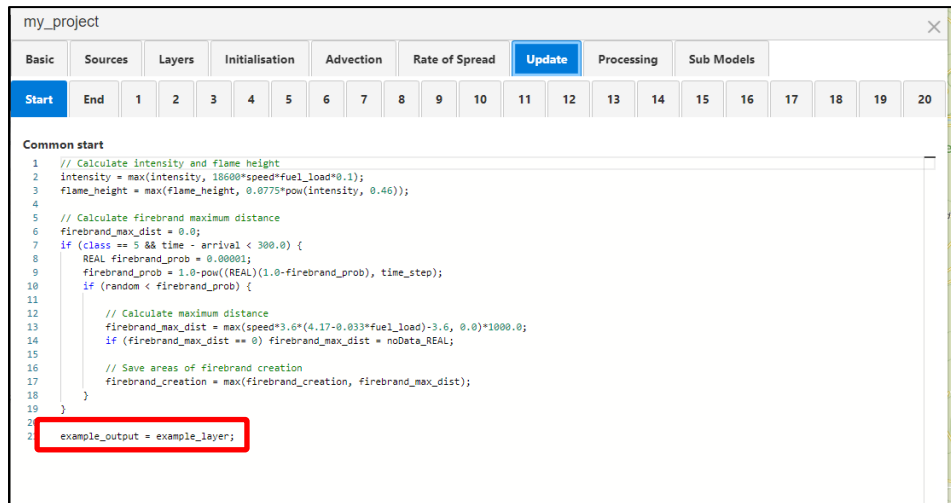
Name	Description	Units	Sampling	Reduction	Flat
model_id	Wildfire spread model ID		Nearest	None	<input type="checkbox"/>
fire_history			Linear	None	<input type="checkbox"/>
fuel_load			Linear	None	<input type="checkbox"/>
intensity	Fire intensity	kW/m	Linear	Maximum	<input type="checkbox"/>
flame_height	Flame height	m	Linear	Maximum	<input type="checkbox"/>
firebrand_max_dist			Linear	None	<input type="checkbox"/>
firebrand_creation	Firebrand creation		Linear	None	<input type="checkbox"/>
example_output	Example output		Nearest	None	<input type="checkbox"/>

➤ Add element to Output Layers

SparkWeb

Advanced usage

- Uploading user data layers
 - *Note, the wildfire platform is currently open. Do not upload any sensitive data as other users will be able to use it. Please use specific filenames to ensure no duplicates (e.g. MY_USER_land_classification_EPSG_XXXX_v1.tiff)*
 - *File is uploaded with the path: /geowebfs/uploads/FILENAME*
 - *Input the correct projection and data type as well as a name which can be referred to in the model scripts.*
- Visualising user data layers
 - *Create an output layer*
 - *Write to the output in a model script*



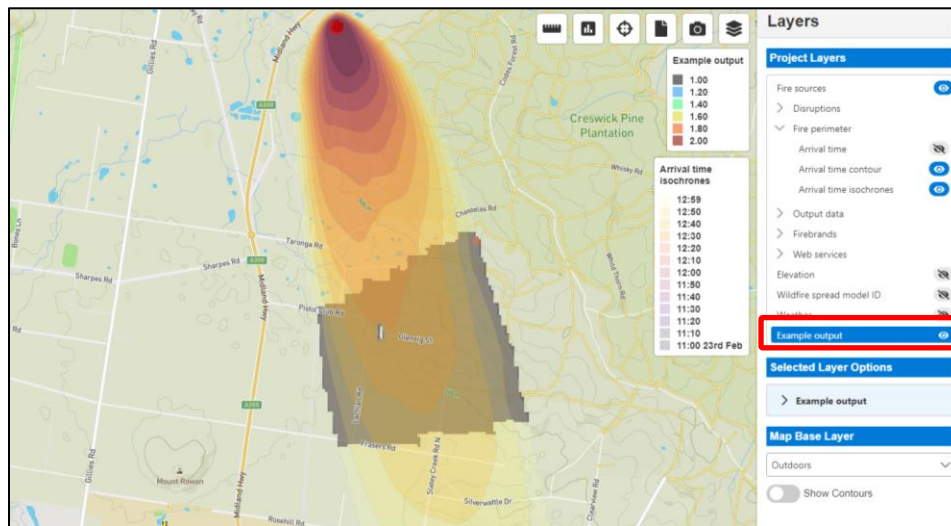
The screenshot shows the SparkWeb interface for a project named 'my_project'. The interface includes a navigation bar with tabs for 'Basic', 'Sources', 'Layers', 'Initialisation', 'Advection', 'Rate of Spread', 'Update', 'Processing', and 'Sub Models'. Below the navigation bar is a timeline with buttons for 'Start', 'End', and numbered steps from 1 to 20. The main area displays a code editor with a 'Common start' section containing a script. The script includes comments and code for calculating intensity, flame height, firebrand maximum distance, and saving areas of firebrand creation. A red box highlights the line 'example_output = example_layer;' at the bottom of the script.

```
1 // Calculate intensity and flame height
2 intensity = max(intensity, 16000*speed*fuel_load*0.1);
3 flame_height = max(flame_height, 0.0775*pow(intensity, 0.46));
4
5 // Calculate firebrand maximum distance
6 firebrand_max_dist = 0.0;
7 if (class == 5 && time - arrival < 300.0) {
8     REAL firebrand_prob = 0.00001;
9     firebrand_prob = 1.0-pow((REAL)(1.0-firebrand_prob), time_step);
10    if (random < firebrand_prob) {
11
12        // Calculate maximum distance
13        firebrand_max_dist = max(speed*3.6*(4.17-0.033*fuel_load)-3.6, 0.0)*1000.0;
14        if (firebrand_max_dist == 0) firebrand_max_dist = noData_REAL;
15
16        // Save areas of firebrand creation
17        firebrand_creation = max(firebrand_creation, firebrand_max_dist);
18    }
19 }
20
21
22 example_output = example_layer;
```


SparkWeb

Advanced usage

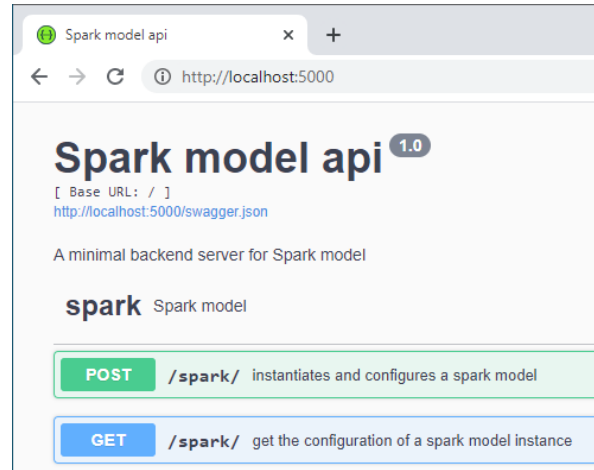
- Uploading user data layers
 - *Note, the wildfire platform is currently open. Do not upload any sensitive data as other users will be able to use it. Please use specific filenames to ensure no duplicates (e.g. MY_USER_land_classification_EPSG_XXXX_v1.tiff)*
 - *File is uploaded with the path: /geowebfs/uploads/FILENAME*
 - *Input the correct projection and data type as well as a name which can be referred to in the model scripts.*
- Visualising user data layers
 - *Create an output layer*
 - *Write to the output in a model script*
 - *Run simulation again to view output*
 - *Your layer name can be used in Initialisation, Rate of Spread and Update models*



SparkWeb

Spark server

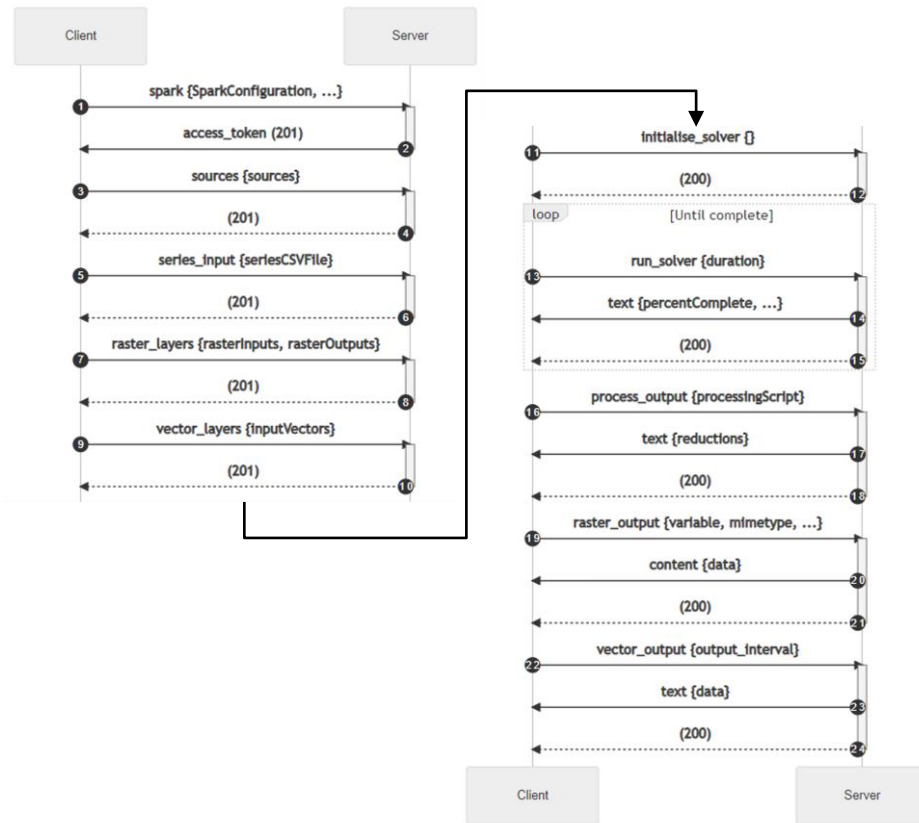
- Web API
 - *Services calls from SparkWeb*
 - *Can be called directly to run simulations/serve outputs*
 - *All models sent to server*



SparkWeb

Spark server

- Web API
 - Services calls from SparkWeb
 - Can be called directly to run simulations/serve outputs
 - All models sent to server
- API calls
 - Documentation and examples available
 - /spark - Initialise solver
 - /spark/sources - Set sources (geojson)
 - /spark/initialise_solver - Initialise solver
 - /spark/run_solver - Run solver
 - /spark/process_output - Custom post-processing
 - /spark/raster_output - Get gridded output (tiff/json)
 - /spark/vector_output - Get vector output (shp/geojson)
 - Success codes 200/201



SparkWeb

Spark server

- Web API
 - *Services calls from SparkWeb*
 - *Can be called directly to run simulations/serve outputs*
 - *All models sent to server*
- API calls
 - *Documentation and examples available*
 - */spark - Initialise solver*
 - */spark/sources - Set sources (geojson)* →
 - */spark/initialise_solver - Initialise solver*
 - */spark/run_solver - Run solver*
 - */spark/process_output - Custom post-processing*
 - */spark/raster_output - Get gridded output (tiff/json)*
 - */spark/vector_output - Get vector output (shp/geojson)*
 - *Success codes 200/201*

```
requests.post(f"http://localhost:{port}/spark/sources", headers=headers,
             json={
                 "sources" : {
                     "features" : [
                         {
                             "geometry" : {
                                 "coordinates" : [ 150.342, -33.6 ],
                                 "type" : "Point"
                             },
                             "properties" : {
                                 "radius" : 120,
                                 "time" : 0
                             },
                             "type" : "Feature"
                         },
                     ],
                     "type" : "FeatureCollection"
                 }
             })
```